VAN NOSTRAND'S
ECLECTIC
ENGINEERING MAGAZINE.

No. II.—FEBRUARY, 1869.—Vol. I.

CHEAP IRON.

The grand requirement of the age is cheap, abundant, and multiform iron; iron at such low prices that constructors can afford to substitute it for weaker and less durable materials, and that all kinds of construction for which iron or its most useful alloy, steel, are alone adapted, will be greatly stimulated. We want iron floors and fronts, iron bridges and sleepers, iron hulls, piers, and forts, and iron framing and facing in general instead of wood. We want steel rails, tyres, wheels, shafting, girders, tension rods, engines, tools and machinery to better resist the wear and strain heretofore inadequately borne by iron. And in addition to these comparatively new and vast applications of iron and steel, we want a greater reproduction of the constructions into which they enter, — *more* steam engines and boilers, more ships and railroads, more iron defences, more agricultural machines, more plant and enginery of every description.

No one thing, not even cheaper coal or cheaper bread, could promote national wealth and progress so directly and rapidly as cheaper iron, for its offices and functions are universal. It shapes, transports, constitutes the physical constructions, and is itself the frame-work of our new civilization. A greater production of iron, even at increased prices, has stimulated commercial and manufacturing enterprises. A vastly greater production at a quarter or half the present cost, would set the world forward a century in a decade.

There is no other subject connected with physical science, of such present absorbing interest, not only to the profession, but to every pursuit associated with or depending upon engineering in its widest sense. The rapid development of new processes, and the promises and expectations of schemers and experimenters in iron and steel, are the *town-talk*. And certainly it is not, as it too often has been, in periods of excitement about new discoveries, all talk. We are entitled to expect immediate results of a character so marked as to visibly better the condition of men and nations. Doubling the life of railroad way and machinery by the use of steel, involves a saving of money that must be universally felt. Reducing the cost of wrought-iron in its almost infinite forms, even to the extent of ten per cent., as seems to be promised by the Ellershausen process, is a blessing as well defined and important as a succession of good harvests.

We devote a considerable space in this number of the Magazine, to articles on various branches of the iron manufacture, and we specially call the attention of blast furnace managers to the subject of *Purifying ores*. Our blast furnace practice most requires improvement, and it would appear to be receiving the least scientific aid, and certainly the smallest amount of experimental inquiry.

Among the more or less developed improvements of the day in the iron and steel manufacture, the Bessemer process, of course, stands at the head. As each new process presents itself, the comprehensiveness of Mr. Bessemer's scheme, and the exhaustiveness of his process, become more apparent. Although soft

and ductile steel cannot be produced by it from irons containing phosphorus, nor malleable steel from irons containing a large proportion of sulphur, yet from the greater number of irons in market, it produces not only good steel, but homogeneous steel, cast from the liquid state. No other direct process develops heat enough to liquify the materials treated, and hence all their products are subject to the structural defects of wrought-iron, to welds and consequent lamination under impact, and a treacherous degree of tenacity under strain. The particular feature of Mr. Bessemer's process, showing the remarkable scope and maturity of his design, is the violent mechanical agitation of the iron under treatment, as a means of promoting the intimate mixture of the oxygen and carbon. All other direct processes are defective in this particular, and hence the heat due to the chemical reaction is not rapid and intense enough to promote fluidity. This is true of puddling in all forms, and of Heaton's and Ellershausen's processes. The mere introduction of air to molten cast-iron is not the principal feature of Bessemer's invention, or rather, it is not Bessemer's invention at all; but the blowing of liquid cast-iron into spray, so that the oxygen can get at all parts of it at once—the mechanical air stirring is the essence of Bessemer's invention.

The Ellershausen process, just now attracting such great attention, and hereinafter described, is too new—its product has been subjected to too few analyses, and its *waste* to too few economical tests, to warrant unqualified confidence, although its remarkable success as far as tried, stops the mouth of the most conservative old fogyism.

The Heaton process, already the subject of endless disquisitions, if not quarrels, in the English papers, is also too little tested to warrant positive conclusions. Its advocates base their statements and arguments mostly on assumptions, and the opposition on *one* set of analyses by the oft-quoted and much pulled about Dr. Miller.

We have referred in another place to the Siemens-Martin process, a proved and established success, and to the Siemens furnace, an accessory to cheap iron and steel, of hardly less value than either of the processes mentioned.

The *refining* of iron is certainly making good progress; we wish we could speak as confidently of the manufacture of pig. This is the weak point in the great scheme of cheap iron. Bessemer may blow, and Siemens may heat never so wisely, but if our smelters do not cultivate more intimate relations with chemical and metallurgical science, the iron millennium will not dawn upon this generation.

UNDERGROUND CITY RAILWAYS.

ENGINEERING DIFFICULTIES — PRACTICAL AND COMMERCIAL SUCCESS—THE LONDON METROPOLITAN RAILWAY.

Under the title of "The Great Railway in Diluvia," "Engineering" gives a graphic account of the difficulties encountered in constructing the Metropolitan Railway, the remarkable energy and success with which they have been overcome, and the extent of the excavations, as compared with other artificial subterranean works, from which we extract the following :—

Beyond the minor troubles to which all railway engineers are born—those with committees, boards, vestries, juries, and the owners and agents of every piece of property at which they dare so much as to look—the underground railway has presented difficulties, at almost every yard, sufficient to make or unmake a professional reputation, according to the success or failure of the attempt to overcome them. The ground had to be studied everywhere, almost, indeed, inch by inch, filled as it was, at so many points, with the gnarled and interlacing ramifications of half-a-dozen gas and water works, and the less easily diverted channels of the metropolitan sewers. In one place a row of houses was ready to move bodily forward into the tunnel; in another a great sewer, although approached but at a respectful distance, was ready to burst and flood a whole neighborhood. This, indeed, actually did happen in the Fleet valley. In Park-crescent a fine house, one in a large sweep of mansions, had to be carefully measured, its every detail drawn, then taken down, and when the railway had been completed just beneath it, rebuilt as before, and so exactly that you could not possibly distinguish it from its neighbors.

GENERAL LIBRARY University of MICHIGAN

The work in carrying the extension line beneath a noble row of houses in Pembridge-square, transferring the bearing of the walls of these houses to a new foundation, was of the highest interest, and displayed great boldness.

The diversion of the large sewers was in many cases a delicate operation. In some instances a 9 feet sewer is carried over, and in others under, the rails. The Ranleigh sewer is carried over a station in a cast-iron tube 9 feet in diameter, between wrought-iron girders having a clear span of 67 feet. Near the Victoria station, the level of the rails is 21 feet 9 inches below high-water mark in the Thames, and a sewer is carried over the railway in a cast-iron tube 14 feet wide and 11½ feet high. The distance from the invert of this sewer to the rails is only 13 feet 7 inches, and it was necessary to arrange the connecting flanges of the plates and the cross girders on the skew, to obtain a sufficient clearance. The tube is protected by a brick arch turned over it, which carries the street traffic. The drainage of the railway is done by pumping-engines.

One of the neatest flights of the invention of which necessity is the mother, was the taking of the extension line beneath the West London Railway, where the difference between the crown of the lower arch and the level of the upper rails was but a few inches, and this without the least interruption of a traffic of 400 trains a day. The operation amounted to taking out the "bottom" of a railway without delaying a single one of the trains almost constantly passing over it. The rails of the West London line were supported upon longitudinal sleepers, carried upon transverse timbers, projecting 7 feet on each side of the trenches that were excavated for the side walls of the low level line; between the transverse timbers the permanent girders were placed, and the side walls built up in detail to their undersides. The length of this crossing is 119 yards. In getting in the foundation of this work, considerable trouble arose from the great depth of the clay below the surface, and it was found necessary to enclose an area of about 920 feet in length, and the width of the railway at formation, with a clay puddled dam 5 feet thick, and varying from 6 to 20 feet in depth.

A little to the west of the Aldersgate-street station stands the now practically completed meat market at Smithfield, the entire area of which at the rail level is converted into a depot, through which runs the Metropolitan Widening, devoted to the service of the trains of the Great Northern, Great Western, and Midland Railways, whilst the London, Chatham, and Dover line makes a junction with it at the entrance to the depot. The size of the market within the retaining walls, which are deeply vaulted, is 625 feet by 240 feet, the vaults serving as valuable storage-room, and the whole of the depot is roofed over with a series of brick arches, turned between a system of girders, resting upon wrought-iron columns. The upper surface of this covering forms the floor of the market on the street level, between which and the platforms of the depot beneath, communication is maintained by fifteen hoists worked by hydraulic machinery, now being completed.

In structure merely, the works upon the Metropolitan Widening, the Smithfield market works in connection with the railway, the bell-mouthed junctions, the portions in which the arch of the tunnel is of iron, and others where the haunches are of iron, together with the extensive employment of iron centering, give special interest to the underground railway, even when examined by the most practical engineer.

The part of the Metropolitan Railway now open has carried its 120,000 passengers in a single day, a traffic hardly within the powers of the 6,000 cabs of London and the 600 *omnibi* of the General Omnibus Company; a traffic not often matched by that over London Bridge, and hardly ever equalled by that carried by the other 10 metropolitan railways taken collectively. There are often, at the same moment of time, 10 well-filled trains on the double line between Bishop's-road and Moorgate-street, containing 3,000 men, women, and children; yet all this vast movement underground is unseen, unheard, and in hardly more than 20 minutes, these thousands reappear in the streets, three, four, or more miles from where they dived into the earth.

A very important consideration—which the citizens of New York will do well to ponder—is that the portion of the London line already open, now *pays*—pays £1,000

per mile per week of gross traffic, and 7 per cent. dividend upon a heavy capital account.

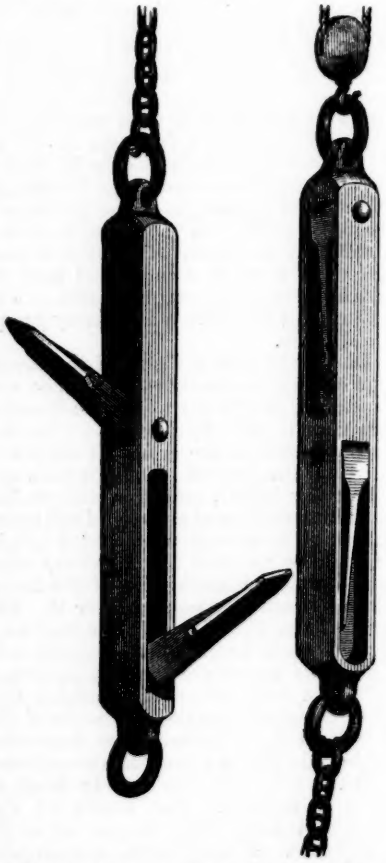
Where the line is fully completed, it will be nearly 8 miles long—a series of tunnels, as long, collectively, as the Mount Cenis tunnel, if not indeed longer, and this besides some few miles of "opens," partly in sloped cuttings, but for the greater distance between strongly buttressed and counterforted retaining walls. Although this tunnel will constitute over 20 acres of cavern—it is small compared with the deserted quarries beneath Paris, quarries now known to have an extent of more than 200 acres, and of which but a comparatively small portion is occupied by the Catacombs. Of building stone alone, upwards of 14,000,000 cubic yards are estimated to have been taken from them. None of our mines of coal or ironstone, have been yet disembowelled to anything like this extent.

"Engineering" adds,—and we beg the people of New York to attend: In New York, the third city in rank in Christendom, and where everybody is in a hurry, and where steam is turned to almost every possible purpose, there is no underground railway, nor is there soon likely to be, although the "down-town" merchants are compelled to ride four, five, or six miles each way, daily, between their homes and places of business.

The Darwinian Theory of the origin of the species is:—First, that variations so slight as not to form distinctive features of classification, are constantly occurring in the reproduction of plants and animals; second, that these variations of form are capable of transmission to progeny, the resulting characteristic generally being intensified in transmission; third, that whenever the variations give their inheritors peculiar advantages in obtaining sustenance, etc., over that possessed by their fellows, they will live longer, will procreate more, and consequently, in the lapse of ages, will extinguish the weaker types. Experiments on plants and animals conducted on this theory, have even in a short time produced astonishing differences in form, color, and habits. This theory, called "natural selection," is gaining ground among naturalists and philosophers.

WITTRAM'S ANCHOR.

The ingenuity of inventors has long been taxed, in the endeavor to produce an anchor which should come nearer than do any of the old style, to the ideal of a perfect ground tackle. The first successful attempt to improve upon the old cumbrous anchor, with its massive shank and flukes, and its huge wooden stock, was made when iron movable stocks were introduced.



The next improvement of importance was the patent known as Porter's, afterwards improved by Trotman, in which the flukes moved on a bolt in the crown. This anchor has been generally adopted in the British Navy, and also in the merchant services of various nations. Recent-

ly, Mr. Frederick Wittram, of San Francisco (now in New York city), has invented an anchor which is radically different from all others. When this anchor is not in use, the flukes lie concealed within the body of the shank like the blade of a pocket-knife, and therefore it can be as compactly stowed as a block of wood of the size of the shank, as shown by Fig. 2 in the engraving. On throwing the anchor overboard, the flukes swing out, as in Fig. 1, and no matter how the anchor falls, one or both flukes are sure to take hold, thus rendering it impossible for the anchor to drag. As there are no projections, such as the stock, or an unused arm, it therefore cannot foul as other anchors frequently do. In weight it is one-third less than ordinary anchors of equal capacity. The repeated tests which have been made of its practical utility have been all highly satisfactory, and it is now attracting much attention from scientific and experienced nautical men.

Rivets.—Mr. Clark, the English bridge engineer, who has made experiments to determine the shearing strength of rivet iron, mentions the fact that rivets, worked hot, contract in cooling, and draw the plates together, thereby causing friction. From this he infers that the value of the rivet is greater than the shearing strength of the rivet iron by the amount of the friction. Later experiments on riveted work show, however, that the value of rivets falls below that given by Mr. Clark for rivet iron, although it includes friction also. Mr. Fairbairn, in his "Useful Information for Engineers," mentions this fact about the friction not appearing to help the rivets, but does not attempt to account for it. Mr. Reed, in his recent work on shipbuilding, explains it by saying that the friction does help the rivet, but that the rivet is much weakened by the working and by contraction during cooling. To show the extent of this, he takes Mr. Clark's values for the shearing strength of rivet iron; experiments at Chatham Dockyard supply the shearing strength of rivets in place (including friction), and some experiments made at Pembroke (which are described in the book) give the amount of the friction; and by deducting the difference between the two last from the first, he gets the amount which the rivet has been weakened. To take an example of a three-quarter rivet:—Shearing strength of the rivet iron=19·52 tons for a double shear; double shearing force of a three-quarter rivet in place=18 tons; mean value of the friction caused by a three-quarter rivet=4.6 tons, from which we find that the shearing strength of the rivet amounts to 13½ tons, or about 6 tons less than the double shearing strength of the iron from which it was made. Mr. Reed conjectures in the text that the principal cause of this loss of strength in the finished rivet is the interior stress of the iron due to the contraction, and he adds that there is probably a further reduction due to the manipulation which the rivet has to undergo in being manufactured and put in place.—*Mechanics' Magazine.*

Supersaturated Solutions.—Mr. Charles Tomlinson, F. R. S., has been experimenting and theorizing upon the subject of the phenomena of supersaturation in saline solutions, and has communicated to the Royal Society his conclusions and the grounds upon which they are based. The conclusions arrived at by Mr. Tomlinson are: (1) That a number of hydrated salts form supersaturated solutions, and remain so even at low temperatures simply from the absence of a nucleus to start the crystallization; (2) That a nucleus is a body that has a stronger adhesion for the salt than for the water which holds the salt in solution, a state of things brought about by the absence of chemical purity; (3) That three or four salts form supersaturated solutions, which in cooling down deposit a modified salt or one of a lower degree of hydration than the normal salts; (4) That this modified salt is formed first by the deposit, in small quantity, of the anhydrous salt, which entering into solution, forms a dense lower stratum containing less water than the rest of the solution, in which lower stratum the modified salt is formed; (5) That salts of a lower degree of hydration form supersaturated solutions, which on reduction of temperature, or by the action of a nucleus, deposit the excess of salt that held the solutions supersaturated, leaving them merely saturated.

WELDING OF COPPER.

Translated from Dingler's Polytechnic Journal, by John B. Pearse.

Mr. Philip Rust, Bavarian Inspector of Salt Works, writes as follows: The great obstacle heretofore experienced in welding copper, has been that the oxide formed is not fusible. Now, if any fusible compound of this oxide could be found, it would render such a weld possible. We find in mineralogy two copper salts of phosphoric acid, viz.: Libethenite and pseudo-malachite, each of which melts readily before the blowpipe. It was therefore natural to suppose that a salt which contained free phosphoric acid, or which would yield the same at a red heat, would make the weld easy by removing the oxide as a fusible slag.

The first trial was made with microcosonic salt (phosphate of soda and ammonia), and succeeded perfectly. As this salt was quite dear, it was found advisable to use a mixture of 1 part phosphate of soda and 2 parts boracic acid, which answered the same purpose as the original compound, with the exception that the slag formed was not quite as fusible as before.

This welding powder should be strewn on the surface of the copper at a red heat; the pieces should then be heated up to a full cherry red or yellow heat, and brought immediately under the hammer, when they may be as readily welded as iron itself. For instance, it is possible to weld together a small rod of copper which has been broken; the ends should be beveled, laid on one another, seized by a pair of tongs, and placed together with the latter in the fire and heated; the welding powder should then be strewn on the ends, which, after a further heating, may be welded so soundly as to bend and stretch as if they had never been broken.

M. Rust had in as long ago as 1854, welded strips of copper plate together and drawn them into a rod; he had also made a chain, the links of which had been made of pretty thick wire and welded.

It is necessary to carefully observe two things in the course of the operation. 1st. The greatest care must be taken that no charcoal or other solid carbon comes into contact with the points to be welded, as otherwise phosphide of copper would be formed, which would cover the surface of the copper and effectually prevent a weld. In this case it is only by careful treatment in an oxidizing fire and plentiful application of the welding powder that the copper can again be welded. It is therefore advisable to heat the copper in flame, as for instance a gas flame.

2nd. As copper is a much softer metal than iron, it is much softer at the required heat, than the latter at its welding heat,—and the parts welded cannot offer any great resistance to the blows of the hammer. They must therefore be so shaped as to be enabled to resist such blows as well as may be, and it is also well to use a wooden hammer, which does not exercise so great a force on account of its lightness.

Hydraulic Dredging.—If sand is drawn along with water into a centrifugal pump, it will be driven forward and thrown out with the water. Messrs. Gwynne, of London, therefore propose, in order to dredge at a depth of over 60 feet for the Bermuda floating dock, to stir up the sand of the sea bottom mechanically, to place their centrifugal pump close to the bottom, and thus to excavate it—pump it out. A large wrought-iron tube, attached to the dredging barge and swinging like the bucket-frame of a dredging machine, carries a pump at the bottom. The shaft that drives the pump passes down the centre of the tube, and carries also a series of screw-blades which stir up the sand. A hood, at the end of the tube, prevents the escape of the sand, so that it is drawn into the pump while momentarily suspended in the water. The work to be done is, simply overcoming the difference of weight between sand and water, raising both a short distance above the water-line, and overcoming the friction of the mass rising in the tube.

Ichabod Washburn, who died in Worcester, Massachusetts, on December 30, has been identified with the manufacture of machinery in this country for nearly half a century. He was as generous as he was successful. Among his gifts were a fund of $200,000, a machine shop fully equipped, and $50,000 working capital, to the Worcester County Institute of Industrial Science.

COMPARISON BETWEEN THE UNIFORMITY OF BESSEMER STEEL AND IRON RAILS.

EXPERIMENTS MADE FOR THE CENTRAL RAILWAY OF ORLEANS AT THE TERRE NOIRE WORKS, AND THOSE OF PETER ASHCROFT, ESQ., ON ENGLISH IRON RAILS.

BY JOHN B. PEARSE.

CONDITIONS.—1. Two ingots shall be taken at hazard out of the same charge and submitted to the subjoined tests in order to ascertain whether their qualities are identical. These trials shall be repeated upon three different charges.

2. Choose any charge as a typical one, and of this take one ingot and submit it to the following tests. Make 6 charges with the object of making them identical with the typical one, and of each of these 6 charges take an ingot and submit it to the same tests, and endeavor to obtain results similar to those obtained from the typical charges.

The desired tests are as follows:

1. The ingots chosen for each series of tests shall be rolled into rails in the ordinary way.

2. Each rail shall be submitted to a deflection test on the following conditions: The rail placed on supports 1 metre apart is to be submitted to pressure in a hydraulic press. Ascertain the deflection under pressure, and the permanent deflection after removal of the pressure.

The hydraulic press used was constructed at Graffenstaden and is fed by 3 pumps worked by eccentrics, whose stroke is so regulated that the supply of water shall be as uniform as possible.

3. Pieces of these rails, of a length of 2 metres, shall be tested by a falling weight under the following conditions:

The rail is placed on 2 supports, the centres of which are distant 1.1 metres from each other; these supports rest directly on a block of iron weighing 10,000 kilogrammes (9 $\frac{1886}{2240}$ tons). The weight of the drop shall be 300 kilogrammes (661.36 lbs.).

The subjoined table exhibits the results obtained in the above series of tests:

FIRST SERIES OF TESTS.

Comparison of Two Ingots from the same Charge.

TESTS UNDER PRESSURE (HYDRAULIC).	CHARGE No. 577.				CHARGE No. 580.				CHARGE No. 581.			
	INGOT A.		INGOT B.		INGOT A.		INGOT B.		INGOT A.		INGOT B.	
	Deflection under Pressure.	Permanent Deflection.	Deflection under Pressure.	Permanent Deflection.	Deflection under Pressure.	Permanent Deflection.	Deflection under Pressure.	Permanent Deflection.	Deflection under Pressure.	Permanent Deflection.	Deflection under Pressure.	Permanent Deflection.
Pressure in Kilogrammes.	Millim.	Millim.	Millim.	Millim.	Millim.	Millim.	Millim.	Millim.	Millim.	Millim.	Millim.	Millim.
15,000	1.7	0.05	1.7	0.05	1.8	0.1	1.8	0.0	1.5	0.0	1.9	0.0
20,000	2.2	0.1	2.2	0.1	2.2	0.1	2.2	0.0	2.0	0.0	2.1	0.0
25,000	3.0	0.4	2.8	0.3	2.7	0.2	2.8	0.1	2.6	0.1	2.6	0.1
30,000	5.2	1.9	4.7	1.9	3.5	0.5	3.6	0.6	3.2	0.2	3.4	0.3
35,000	10.8	7.5	8.9	5.3	5.8	2.3	6.0	2.3	5.3	1.6	4.8	1.1
40,000	15.8	11.9	16.8	12.6	10.5	6.4	11.3	7.2	9.8	5.5	9.4	5.2
Limit	Kilog. 55,000	Millim. 60	Kilog. 54,100	Broke.	Kilog. 56,500	Broke.	Kilog. 56,500	Broke.	Kilog. 61,500	Millim. 60	Kilog. 62,000	Millim. 58

DROP TESTS.	Deflection after Blow.	Deflection after Blow.	Deflection after Blow.	Deflection after Blow.	Deflection after Blow.	Deflection after Blow.
Fall in Metres.	Millim.	Millim.	Millim.	Millim.	Millim.	Millim.
1,500	5	5	4	4	4	4
1,750	11	10	10	10	9	9
2,000	19	19	16	17	16	14
2,250	27	27	25	24	23	23

Second Series of Tests.

Comparison between Seven Ingots of Different Charges.

TEST UNDER PRESSURE (HYDRAULIC).	TYPE CHARGE, 564.		CHARGE, 582.		CHARGE, 585.		CHARGE, 586.		CHARGE, 589.		CHARGE, 590.		CHARGE, 594.	
	Deflection.		Deflection.		Deflection.		Deflection.		Deflection.		Deflection.		Deflection.	
	Under pressure.	Permanent.	Under Pressure.	Permanent.	Under Pressure.	Permanent.	Under Pressure.	Permanent.	Under Pressure.	Permanent.	Under Pressure.	Permanent.	Under Pressure.	Permanent.
Kilogrammes.	Milli.	Milli.	Milli.	Milli.	Milli.	Milli.	Milli.	Milli.	Milli.	Milli.	Milli.	Milli.	Milli.	Milli.
15,000	1.6	0.1	1.7	0.1	1.8	0.1	1.8	0.1	1.9	0.1	1.6	0.0	1.7	0.0
20,000	2.2	0.2	2.2	0.2	2.2	0.2	2.3	0.1	2.4	0.2	2.1	0.1	2.1	0.1
25,000	3.5	1.1	2.9	0.3	3.3	0.7	2.9	0.3	3.2	0.4	3.2	0.8	2.8	0.3
30,000	11.2	8.5	4.7	1.0	7.2	3.9	5.1	1.8	5.6	2.2	11.6	8.5	5.0	1.9
35,000	23.6	21.0	10.0	6.4	16.2	12.1	11.4	7.6	15.2	11.2	25.0	21.3	12.4	8.7
40,000	40.6	36.1	18.6	14.0	29.0	24.1	20.8	16.5	26.8	22.5	45.0	40.4	22.7	18.2
	Kilog.	Milli.	Kilog.	Milli.	Kilog.	br'ke	Kilog.	br'ke	Kilog.	Milli.	Kilog.	Milli.	Kilog.	Milli.
Limit	50,000	80	59,000	63	50,200		44,500		54,000	70	49,500	74	56,200	65

DROP TESTS.	Deflection after Blow.	Deflection after Blow.	Deflection after Blow.	Deflection after Blow.	Deflection after Blow.	Deflection after Blow.	Deflection after Blow.
Fall in Metres.	Millim.	Millim.	Millim.	Millim.	Millim.	Millim.	Millim.
1.500	7	6	4	7	6	7	5
1,750	15	13	14	15	14	15	14
2,000	26	23	25	26	25	26	25
2,250	37	31	33	37	35	37	36

The following conclusions flow naturally from the above tests :

1. The first series demonstrates the practical identity of 2 ingots chosen at random from the same charge. The regularity of the results is remarkable up to the pressure of 25,000 kilogrammes (about 25 tons), which represents quite nearly the *limit of elasticity.*

Above this limit the differences are still inconsiderable compared to weights (or pressure amounting to weight) borne.

2. The first series develops a remarkable regularity in the charges, although not made with the object of proving any identity.

Charge 581 is a little harder than the others, but the results up to the limit of elasticity do not vary much from those given by the other ingots, and the variation is too inconsiderable to have any practical influence.

3. The second series shows the practical identity of the 6 ingots with the 7 or *type* ingot. The latter is a little softer than the ingots of the 3 charges in the first series. It was made so designedly, and its qualities were reproduced quite closely, as the differences in the permanent deflection or set are within a few tenths of a millimetre. As in the previous series, the differences become great only when the limit of elasticity is passed.

4. The drop tests show uniform results, which are in harmony with those given under pressure. The variations bring out the slight differences in the hardness of the various ingots. For example, the metal of charge 581 is a little stiffer than that of charges 577 and 580. It is also apparent that the ingots of the second series were softer than those of the first.

The experiments were conducted with every care, by the engineers of the Terre Noire Works in presence of M. Delom, engineer of the Orleans road, on the part of the railway company.

These results are very interesting as showing a practical identity in the products of the Bessemer process. It would be difficult to find any such series of iron

Name of Rail or Maker.	Weight per Yard.	Weight of Ram.	Number of Blows.	Blows Increasing by Foot as under.	Result of Blows.	Turned or not, before Breaking.	Greatest Deflection whether Turned or not.	REMARKS.
Derwent	....	309 lbs.	3	4 ft. to 6 ft.	Broke	Not turned	5-16	Too cold short.
Do., another rail	....	"	5	4 ft. to 8 ft.	"	"	7-8	Ditto.
Do., a third rail	....	"	11	4ft. to 14 ft.	"	"	3 3-8	Both good and safe.
Barmingham's	73 lbs.	3 cwt.	2	8 ft. and 9 ft.	"	"	3 8	Bad.
Do.	78 lbs.	"	8	8 ft. to 15 ft.	"	Turned ...	3 11-16	Good.
Same rail turned	"	"	6	all 15 ft.	Nearly straight	" ...	.....	Good.
Same rail turned	"	"	2	all 15 ft.	Broke	.....	1-2	
Hopkins'	82 lbs.	"	2	8 ft. and 9 ft.	"	Not turned	1-4	Bad.
Do., another rail	75 lbs.	"	5	8 ft. to 12 ft.	"	"	1 13-16	A very good sample.
Plymney	....	300 lbs.	4	8 ft. to 11 ft.	"	"	1 1-16	Rather too cold short.
Do., another rail	....	"	3	8 ft. to 10 ft.	"	"	5-8	Ditto.
Do., a third rail	....	"	7	8 ft. to 14 ft.	"	"	2 3-8	A safer rail with a fine granular head.
Do., a fourth rail	80 lbs.	3 cwt.	2	5 ft. to 6 ft.	"	"	1 16	Very cold short and questionably safe.
Ebbw Vale	....	"	7	all 10 ft.	" ...	"	2 5-8	
Do., another rail	....	"	7	all 15 ft.	"	"	4	
Do., a third rail	....	"	10	all 10 ft.	"	Turned ...	4 1-8	
Do., same rail turned	....	....	9	three of 10 ft., six of 15 ft.	"	.....	.....	
Aberdare	75 lbs.	3 cwt.	1	5 ft.	"	Not turned	.....	Bad.
Do.	82 lbs.	"	1	4 ft. 6 in.	"	"	.....	
Do., another rail	....	"	6	10 ft.	" ...	"	1 1-16	
Do., another piece of same rail	....	"	1	5 ft.	"	"	.....	
Do.	81 lbs.	"	11	5 ft. to 15 ft.	"	Turned ...	2 15-16	A very good rail, fine and granular, indicating long wear.
Same turned	....	"	2	both 5 ft.	"	.....	.....	
Blenavon	82 lbs.	300 lbs.	2	4 ft. and 5 ft.	"	Not turned	1-16	
Do., another rail	81 lbs.	"	1	4 ft.	"	"	.....	Entirely rotten or extremely hard.
Do., another rail	60 lbs.	"	7	5 ft. to 11 ft.	"	"	2 1-2	Very good.

rails made with puddled steel or hard iron heads. The following series of tests made by Mr. Peter Ashcroft, engineer to the South Eastern Railway Company, shows how much iron rails made by the same companies may vary in strength. The tests are classified according to the company upon whose rails they were made. The remarks are those of Mr. Ashcroft.

These trials were published in "Engineering" and have been rearranged for the purpose of showing distinctly how much the rails of each maker varied. The tests show that the majority of the rails tried excepting those of one company (Ebbw Vale) were extremely brittle and unsafe. It is very probable that the slabs which are made from old rails and used in the formation of the rail piles vary greatly in quality and may indeed be altogether different; that is, one slab might easily be cold short, while its neighbor was red short. It would not be improbable to suppose that in some parts of the country a rail pile might easily be composed of slabs from rails of 3 or 4 different makers, with tops and bottoms puddled and rolled at the mill. Now such a rail would be composed of layers of different material varying in strength, and it is quite natural to conclude that some of the layers would be so weak as to partially destroy the strength of the rail itself, by giving way before the stronger parts had been materially strained. That is, a strong flange is of no use with a web which would give way on strain, or a head which was made so hard as to crumble on the reception of a blow, or under the constant succession of blows to which it is exposed in the track. It is also probable that a pile may be so heated as to be burnt in some parts while quite sound in others, while the temperature at which it is necessary to weld the slabs together is so near that at which they may be burnt, that many tons of piles have been burnt in the furnace by the mere change of the light in which the furnace was placed. When the poor quality of iron used for rails is taken into consideration along with the manner in which the same is worked up, it is quite obvious that a great deal of irregularity is natural to the whole series of operations.

THE ELLERSHAUSEN PROCESS.

The recent and remarkable invention of Mr. Ellershausen, which is now regularly in use in Pittsburg, and is being rapidly introduced all over the country, has greatly advanced the solution of this important problem. So many new steel and iron processes are brought to notice every day, that the unprofessional reader cannot keep track of their names and aims. The value of this process may be inferred from the fact that a no less respectable Board of Trustees than Messrs. Asam L. Hewitt, E. B. Ward, Jas. Harrison, Jr., and several Pittsburg iron masters, are now granting licenses under the Ellershausen patents.

The process consists in the conversion of crude cast iron, as it runs from the smelting furnace, into wrought iron, by the simple admixture of granulated iron ore. It is carried out at the works of Messrs. Shonberger, at Pittsburg, in the following manner: On the casting-floor of the smelting furnace a cast-iron turn-table, about 18 ft. in diameter, is revolved on rollers by a small steam-engine. Upon the outside edge of the table stand a row of cast-iron partitions, forming boxes, say 20 inches wide and 10 inches high, open at the top. Just above the circle of boxes stands a stationary, wide-mouthed spout, terminating in the tap-hole of the furnace. When the furnace is tapped, the liquid iron runs down this spout and falls out of it in a thin stream into the boxes as they slowly revolve under it, depositing in each a film of iron, say one-eighth of an inch thick. But, before the fall of melted iron reaches the boxes, it is intercepted, or rather crossed, at right angles, by a thin fall of pulverized iron ore, which also runs out of a wide spout from a reservoir above. These two streams or falls are of about equal volume, say one-quarter of an inch deep and 20 inches wide. A workman, with a bar in the tap-hole, regulates the stream of iron, and the iron spout from which the liquid metal falls into the boxes is removable; other spouts, previously coated with loam and dried, being attached to a common revolving frame, so as to be ready for use when the loam covering of the first becomes cracked or removed.

The thin layers of iron and ore soon chill and solidify, so that by taking away the outer partition of the boxes (which form the rim of the turn-table), they may be removed in cakes of the size of the boxes, and weighing about 200 lbs. each. Four of these cakes or blooms are put into a reverberatory puddling or heating furnace, and raised to a bright yellow heat. They will not melt at this heat, but become softened so as to be easily broken up with a bar. The four blooms are formed, in the furnace, by the "rabble" of the workman, as in ordinary puddling operations, into eight balls. The balls are brought out, one after another, squeezed in the ordinary "squeezers" to expel the cinder and superfluous ore, and then rolled into wrought-iron bars, which are now ready for market, or for further reduction into smaller finished forms.

The chemistry of the operation is as follows: The crude cast-iron contains say 5 per cent. of carbon and 2 per cent. of silicon, and more or less sulphur, phosphorus, and other impurities. In the Bessemer process, the oxygen of the air, blown into the liquid iron, combines with this carbon and these other impurities, and not only removes them, but leaves the pure iron in a liquid state, from which it can be cast into homogeneous masses of any size. In the puddling process, the oxygen of the air and of the ore, or other "fettling" put into the furnace with the iron, combines with and eliminates the impurities, which are afterward squeezed out of the pasty mass by the squeezers and rolls. This process is long and comparatively expensive, because the mixture of oxygen or oxygen-bearing substances is not made intimate with the iron except by long stirring, which is not only skilful, but exhausting work.

In the Ellershausen process, the oxygen of the ore or oxide of iron (magnetic oxide is preferred) combines with the carbon and impurities, eliminating them as in the puddling process, and the iron of the ore increases the product. The chemical combination of the ore and the liquid crude iron appears to take place partly at the time of their contact when falling and lying upon the turn-table, and partly where the reheating occurs in the furnace. It seems impossible that a reaction which is so violent in the Bessemer process, and so prolonged in puddling, should take place so quickly and quietly in the new process; but the fact that the cakes of

iron and ore do not melt by subsequent heating, as cast-iron would, proves that its nature is changed by the first contact of the ore. The removal of sulphur and of phosphorus also seems more thorough than in the other processes. Analyses at different stages of the operation will throw more light on this question.

The remarkable feature of the Ellershausen process is that absolutely no skill is required to carry it out. The proportion of ore mixed is intended to be about 30 per cent; but if too much is added, it is readily squeezed out with the slag, and seems to do no harm. The subsequent heating occupies about half an hour. "Puddle bar," the product obtained from the first rolling of the product of the puddling furnace, is never marketable or finished iron. It is usually very ragged and unsound, and requires subsequent piling, reheating, and rerolling, to expel the impurities and to give it soundness and solidity. The new process appears to produce merchantable iron at the first rolling, and, at Pittsburg, from a very inferior pig-iron, made of one-half sulphurous Canada ores, and one-quarter Lake Superior and one-quarter Iron Mountain ores.

The thoroughness and rapidity of the purification by this process evidently depend on the intimacy of the mixture of iron and ore. This intimate mixture is also the essence of the Bessemer process. In fact, to Mr. Bessemer's original apprehension of this idea of intimate mechanical mixture, the greatest modern improvements in the iron manufacture are due.

The Ellershausen process is said to decrease the cost of wrought-iron from $10 to $20 or $30 per ton, according to the materials used and the form of product required. That it is a success is amply proved by regular working at Pittsburg and many experiments elsewhere; and if anything like this economy can be realized, its value to the public will only be exceeded by that of the Bessemer process. The latter process, however, produces *steel*, which is absolutely homogeneous and of regulated hardness, according to the wear and service required, and hence indispensable for rails, tires, and various machinery purposes. Any iron product that is not *cast* from a liquid state, is subject to all the structural defects of ordinary wrought-iron.—*New York Times.*

ENGINEERS IN PARLIAMENT.—"Never," says "Engineering," "have the most important industrial interests of the kingdom been so fully represented as in the new Parliament." It includes, engineers, contractors, ironmasters, manufacturers and the owners of collieries. Among them are, Mr. George Elliott, Prest. of the North of England Inst. of Mining Engineers, an ironmaster who finds employment for 10,000 men; Mr. John Lancaster, Chairman of the Mining Association of Great Britain, head of the Wigan Iron and Coal Company, and less favorably known in America in connection with Captain Semmes of the Alabama; Mr. Richard Fothergill of the Taff Vale Ironworks; Mr. A. C. Sheriff, chairman of the Metropolitan District Railway; Mr. Joseph D'Aquilar Sumuda, Shipbuilder; Sir Daniel Gooch, late Locomotive Superintendent of the Great Western Railway; Mr. John Robinson McClean, late President of the Institution of Civil Engineers; Mr. John Platt, Manufacturing Engineer; Mr. John Hick, Engine-builder; Mr. John Laird, Shipbuilder; Dr. Lyon Playfair of the University of Edinburgh; also, Messrs. John Miller, Charles E. Cawley, Sir Richard Atwood Glass, Messrs. Thomas Brassey, James Howard, and Charles Seely, Engineers, and Messrs. Bolckow, Brogden, Beaumont, Winn, Plimsoll, Rylands and Samuelson, Ironmasters.

THE UPPER HUDSON—SLACKWATER NAVIGATION.—The report of the State Engineer for 1867 embodies the report of the surveys made in 1866 by Samuel McElroy, C.E., for the improvement of the Hudson river for slackwater navigation from Troy to Fort Edward, about 40 miles, and a corresponding improvement of the Champlain Canal from Fort Edward to Lake Champlain, about 25 miles, with locks 225 feet by 30½ feet, adapted to 8 feet water-way; and also the comparative cost of improving the Champlain Canal from Troy to Whitehall, with locks 225 feet by 25, and 7 feet water-way. It appears that a dam at the Highlands, 150 feet high, would turn the stream into Lake Champlain and the St. Lawrence; that the remedy which New York harbor needs for the difficulties of navigation at

Hell Gate from the swift tidal currents, and at other points for ice fields and deposits of silt, and at Sandy Hook, would be found by connecting New York and Brooklyn with a masonry dyke say 400 feet wide, with 2 or more ship locks, and by making a ship canal of the Harlem River, so that the whole volume of the North River could go out to sea, and the present tidal flux and reflux be prevented on the East River, and the facilities of Sound and river commerce be turned into their natural channel at the head of New York Island. This would also solve effectually the problem of connecting New York and Brooklyn.

It is also proposed to examine the gorges of the Hudson river above Fort Edward, to determine the feasibility of a plan for retaining the freshet supplies, so as so prevent the periodical floods which have always proved so destructive above Albany.

The details of the report show that on a comparison of the items of cost, the sum of $4,534,379 will secure 8 feet water-way by the river plan, from Troy to Whitehall, while it will cost $5,866,851 to secure 7 feet water-way by the canal plan, and that the "commercial, military, and mechanical advantages are distinctly in favor of the river plan;" the value of the developed mill power alone being shown to be about $4,334,600.

NEW SYSTEM OF BOILING SUGAR.

In an ordinary vacuum pan, the top of the liquid alone forms the evaporating surface, and evaporation would, of course, be more rapid were a greater portion of the liquid exposed. An improvement by Mr. Tooth consists in pumping the juice down from the top of the vacuum pan, at the moment of granulation, through a rose. The juice is thus distributed in small streams through the air contained in the evaporating vacuum chamber, and the surface exposed, as compared with the old system, is said to be as 1,000 to 50. The evaporating chamber differs from the old vacuum pans in shape, being, to speak roughly, a long cylinder, with the ordinary round pan at the top and bottom. The juice, before reaching the evaporating chamber, is pumped up through a number of pipes surrounded by steam in a cylinder. The following advantages are stated by the inventor to be secured by this process: 1. The juice is protected from excessive and long-continued heat. 2. Long exposure to the injurious influence of the atmosphere is avoided. 3. Great rapidity in carrying on the evaporation is secured. 4. The juice is transferred to the vacuum pan (or evaporating chamber) immediately after defecation and filtration, avoiding the necessity of open pans. 5. Any extent of heating and evaporating surface is easily obtained. 6. The cost of fuel is greatly lessened. 7. Vacuum pans now in use may be made available for the improved system at a comparatively small cost. 8. The finest sugar is produced without the expense of animal charcoal, and the crystallization being perfect, there is no loss by drainage. 9. There is no formation of molasses beyond that naturally existing in the juice, as the temperature never need exceed 140° to 160° Fahr. 10. The system is also useful in beetroot sugar manufactories. There is an arrangement by which the clogging of the rose, through which the partly-granulated sugar passes, is remedied. The idea of exposing a greater surface to evaporation seems to us excellent in theory, but it belongs, of course, to practical men to say if it will work. Mr. Tooth has another patent to compete with Mr. Fryer's boncretor, for rapid and cheap evaporation. This consists in passing the partially granulated juice through a rose, and letting it drop down through a long cylinder or tower filled with heated air. The patentee states that the juice reaches the bottom in the shape of sugar.—*Produce Market Review.*

ANOTHER GREAT EASTERN.—Mr. Thomas Silver has designed a ship of Great Eastern proportions except as to depth; the draft is to be 18 instead of 28 feet. The vessel is intended to carry 4 times as many passengers as the present Cunarders, and to have Christian beds and rooms for their accommodation.

HIGH-LIFT CENTRIFUGAL PUMP.—Messrs. Gwynne & Co., London, are constructing a centrifugal pump, to draw from a depth of 18 feet and force over a standpipe 114 feet high—the greatest lift yet attempted with this kind of machine. The pump has a disc 2 feet in diameter, and is to run at 910 revolutions per minute.

RECENT CIVIL ENGINEERING WORKS.

BRIDGES, HARBORS, AND DOCKS.

Compiled from "Engineering," and other authorities.

ENGLISH BRIDGES.—In England two fine bridges were completed and opened in 1868. The great bridge of the London and North-Western Railway over the Mersey at Runcorn, besides its long approaches, has three spans of lattice girders of 300 feet clear opening each. The construction of this bridge presents no new feature of interest.

The Solway viaduct, carried out upon the plans of Mr. James Brunlees, is about a mile in length. It has 161 spans of 30 feet each of light wrought-iron girders, besides a swing bridge giving two 50 feet openings. The bridge is supported upon cast-iron piles, driven through the shifting sand into the gravel below. About 1,900 tons of wrought, and 2,300 tons of cast iron have been worked into this structure.

The new bridge at Blackfriars (pronounced by the President of the Institute of British Architects, the "ugliest bridge of its size in Europe") has a central arch of 185 feet, besides 2 arches of 175 feet, and 2 of 155 feet. The arches are of wrought iron; the foundations have been built up in caissons; the width between parapets is 75 feet. The bridge is nearly completed.

No masonry bridges are in progress, and it is the opinion of some of our best engineers that the age of stone has ended, and that iron has permanently taken its place. No one of our English bridge engineers has yet adopted steel; but this is best explained by the fact that while steel is so much more costly than iron, its great advantage—that of saving weight—is shown chiefly in the case of large spans, and no long span bridges are now in course of construction in England.

AMERICAN BRIDGES.—For large bridge works in progress we are to look abroad. In America the widest span of suspension bridge yet achieved—viz, 1,268 feet—has been carried over the Niagara river, almost immediately below the great cataract, and nearly two miles above the railway suspension bridge. The length of suspended platform is 1,240 feet; height above the water, 190 feet; length of part resting directly on cables, 635 feet; height of towers, 100 and 105 feet; base of towers, 28 feet square; width of roadway, 10 feet. The 2 cables are 7 inches diameter each. The weight of the suspended load is 250 tons. The work was designed and carried out by a Canadian engineer, Mr. Samuel Keefer.

Two other great suspension bridges are proposed in America, and it is confidently anticipated that both will be begun and completed. The East River Bridge at New York, projected by Mr. John A. Roebling, is to have a single suspension span of 1,600 feet, and to be in all one mile in length. The height of the roadway is 130 feet; width, 80 feet; height of towers, 263 feet. The Cornwall (railway) bridge is to be carried over the river Hudson, at some distance above New York, in a single span of 1,800 feet; height above water, 155 feet; height of towers above water, 280 feet; total suspended weight, 9,651 tons. The last-named work has been designed by Mr. Julius W. Adams, who has a high reputation in America as a sound and successful engineer, his name alone being sufficient to protect the undertaking in question from any suspicion of its being a mere idle scheme.

Of the iron bridges in progress in America, one over the river Ohio at Louisville, will be one mile in length, and, besides a number of smaller spans, will have 2 of 370 feet each, 6 of 245 feet 6 inches, two of 227 feet, three of 210 feet, &c.* A timber bridge for railway purposes, lately completed over the river Mississippi, at Quincy, has a pivot span upwards of 360 feet long, covering two openings of 180 feet each.

One of the most important works yet commenced in the United States, is the great railway and roadway bridge over the river Mississippi at St. Louis. This work has been fully described and discussed in the last volume of "Engineering." As designed by Capt. Eads, it is to have three arches of steel, the middle arch being of the enormous length of 515 feet.

The iron bridge just completed over the Mississippi at Dubuqe, was built from the designs of J. H. Linville, Esq., President of the Keystone Bridge Co. It consists of 7 spans, 2 of 250 feet, 4 of 225 feet, and 1 of 360 feet resting on the pivot pier, leaving the opening 160 feet

* For particulars see "Engineering," Vol. V., page 506.

wide on each side of the pier. The total length of the bridge is 1,760 feet, or exactly one-third of a mile. The truss is 28 feet high and 16 feet wide in the clear. The lower chord is 31½ feet above low water. The eastern approach is through a tunnel 835 feet long.

Continental Bridges.—On the Continent the finest bridge completed and opened during the year, is Mr. R. M. Ordish's elegant work, the Franz Joseph rigid suspension bridge over the Moldau, at Prague. This is the first practical embodiment of a principle for which Mr. Ordish has contended for so many years, that of straight inclined suspension rods, with a light curved chain to support their own weight in so far as to prevent sagging. This bridge, with a span of 492 feet between centres of towers, a vertical depth between centres of suspension rods of 61 feet 3 inches, and a total length of 820 feet, has been heavily tested with a very moderate deflection, while it possesses also great steadiness under passing loads.

Among the Continental works nearly finished, and soon to be opened, is the magnificent railway bridge in Holland, at Kuilenburg, over the Lek, one of the channels by which the river Rhine reaches the North Sea. Engravings and particulars of this great work are soon to be published in "Engineering." The bridge has one great span of 492 feet, one of 262 feet, and 7 of 187 feet each. The total length is 2,181 feet, and the contract price was £153,000. The girders spanning the great opening are 515 feet long, and 65 feet 6 inches deep.

The railway bridge over the Danube at Vienna will be an important work; comprising 5 spans of lattice girders of 262 feet opening each, and 4 other spans of 112 feet.

The Dutch Government will eventually construct, although they have not yet commenced, the great railway bridge over the main outlet of the Rhine at Moerdyk, between Antwerp and Rotterdam. This bridge will be a mile in length, and it has been proposed to make it in spans of 400 feet each. "Engineering" says:—As compared with such works, there are at present no hopeful schemes in England. Mr. Fowler's proposed great 2½ mile bridge over the Severn, with its 600 feet central span, its 245 feet side spans, its thirty 150 feet spans, its twenty-six 120 feet spans, and its twenty-seven 90 feet spans, is still in abeyance, but it will be built *some time*. It is true we have the frantic Boutet seeking to excite capital for the construction of a 10-span bridge across the English Channel, with openings *only* 3,282 yards (!) in the clear, and it is such schemes, stamped with ignorance, impudence, and infatuation, that sicken the heart and madden the brain of the true engineer.

Harbors and Docks.—A large number of important harbor and dock works were completed last year. The Millwall Docks, by Mr. John Fowler and Mr. William Wilson, comprise 2 basins of 25 acres and 10½ acres respectively, and a graving dock 402 feet long, and 86 feet wide, with an entrance of 65 feet. The graving dock has "bilge carriages," so arranged as to be run under a ship to keep her keel off the ground. These docks have 28 feet of water and 7,700 feet of quay frontage. This work, replete with the latest inventions necessary to afford the most perfect and complete accommodation for vessels, is furnished throughout with the Elswick hydraulic machinery for which Sir William Armstrong & Co. have become famous. A very fine specimen of the telescope bridge is found here, of probably 80 feet span, and which, actuated by water pressure, rises from its bearings and slides endways from off its span, when called on, with incredible facility.

The Sutherland Docks have been extended by Mr. Thomas Meik. The new Hudson basin is 11 acres in extent; the new outer harbor has been enlarged to 28 acres. The Leith Docks, by Mr. George Robertson, are nearly completed; also the new Western Dock at Hull, by Mr. John Hawkshaw. The Tyne Improvement Works, by Mr. Ure, are progressing. About 4,000,000 tons of material are being dredged yearly, at a cost of rather more than 4d. per ton, and the whole yearly expenditure, including that upon the Great Tyne piers, is about £250,000. A large graving dock* is in course of construction at Hebburn, Gateshead.

The Admiralty works in progress at Chatham, under the direction of Colonel Clarke, will involve an outlay of £1,500,-

* See "Engineering," December.

000, and comprise the reclamation of St. Mary's Island, 300 acres in extent, the construction of 3 basins of respectively 22, 20, and 37 acres, the construction of large graving docks, slips for laying up frigates, etc., and an immense steam factory, 1,000 feet by 700 feet. The new dock in French Creek, Malta, is also progressing under the same direction.

Among proposed harbor works, the improvements at St. Helier's, Greenock, and Scarborough, have attracted the greatest attention among engineers. The Greenock works to be carried out, comprise a large basin, graving dock, extensive quays and warehouses, and special arrangements for shipping large quantities of coal. At Scarborough, the only work proposed is a pier, enclosing on one side a harbor larger and better than at present.

The Clyde Trustees have decided upon the construction of a graving dock of great size, viz., 503 feet long, 100 feet wide, and 30 feet deep, the entrance to be 83 feet wide. New harbor works are to be at once commenced at Aberdeen, and additional works are proposed at Dublin, at Newport, Cardiff, Llanelly, and at Porthcawl.

A new graving dock is building at Williamstown, Victoria. Its dimensions are to be 240 feet by 97 feet, with an entrance 80 feet wide.

Mr. Hawkshaw is constructing the Grand Canal to connect Amsterdam direct with the North Sea, so that ships from the Dutch capital will strike deep water a little to the north-west of Harlem, instead of beating miles out of their way around the Helder.

Nor should the works in progress at Havre be forgotten. The seven basins, as fine in their way as anything in Europe, are to be still further extended, and Messrs. I. C. Johnson & Co., of Gateshead-on-Tyne, have a contract with the French Government for 20,000 tons of Portland cement for these very works.

THE BERMUDA FLOATING DOCK.—During the year a great iron floating dock, capable not only of taking the largest ship in the navy, but of careening her as well, has been completed for Bermuda. This structure is 381 feet long, 124 feet wide, 72 feet deep, and weighs 9,000 tons.* This is a double dock, one within the other, the sides or "double skins" being 20 feet apart, and enclosing respectively a load chamber, balance chamber, and air chamber. Water may be pumped into or from either of these chambers, so as to sink, lift, or tilt the dock as desired. This great work, designed by Colonel Clarke, of the Admiralty, was constructed and, after a slight hitch, successfully launched by Messrs. Campbell, Johnstone & Co., of North Woolwich.

The hydraulic graving dock, of which the first example was erected ten years ago at the Victoria Docks, is having new innings. One has just been sent out to Bombay. It has 36 hydraulic presses in all, each of a force of 400 tons, so that the total lifting power is 14,400 tons, and including its "saucer" it will thus lift the heaviest ship in the navy. Docks upon the same plan are spoken of for Jamaica, Malta, Brindisi, and Dundee.

THE HOLYHEAD PIER.—At Holyhead the great breakwater pier approaching completion, under Mr. Hawkshaw's auspices, is a noble specimen of marine engineering. It is constructed chiefly of stone taken from the mountain adjacent. The upper structure is of random-worked ashlar, presenting a flush face on the inside or harbor front, while on the sea face the material is quarry-faced, and, as far as may be practicable, set on end, giving it the appearance of being vertically ribbed. The base of the pier consists of *pierre perdue*, having a slope, of the angle of repose of the material, on the inside, while on the outside its form is that of a flat glacis, on which the sea must lash with intense fury, as the stone is much pulverized by its action, especially so in the gorge caused by the re-entering angle of the work. The plan of the work is that of a continuous wall, of 1½ mile long, zigzag, with 2 kants springing from the land at one end, and at the other resting in 13 fathoms of water at low tide. The upper structure carries a causeway of 38 feet wide, at 12 feet above which, on the seaside, there lies a banquette of 15 feet wide, floored with tooled limestone, and surmounted by a parapet of 4 feet high, of the same material and class of workmanship; which latter throughout appears to be as near perfection as possible. The high level is connected with the causeway by flights of stairs at intervals. From the base of the parapet on the external face

* See "Engineering," Oct. 19, 1866.

projects an echinus of 2 feet overhang, which, however it may add to the effect of the sectional profile, will surely meet with rough usage from the waves towards the extremity of the pier. Here green water of yards thickness comes over the parapet during a gale. The pier head is not yet completed. It will be, in plan, of a T section, the arms of the T showing a very slight projection, and rounded at the ends. The face-work here will be of granite blocks, of from 8 to 12 tons weight each; the hearting of red sandstone, of the same dimensions.

Port Saïd Harbor.—Extensive harbor works are, it is understood, to be undertaken, by an English company, at Alexandria. The works are to comprise a breakwater 3,250 feet long, a mole 1,650 feet long and 200 feet wide, 5,000 feet of quays, and a large dry dock. To the east of Alexandria is the new harbor of Port Saïd, at the northern end of the Suez Canal, the later now more than two-thirds finished. Port Saïd, now nearly completed, is formed by two piers, one 2,730 yards and the other 2,077 yards long, with an opening to the north-east. The harbor enclosed is nearly one square mile in extent, and the western pier is carried out into water 27 feet 6 inches deep. These piers have been formed of *béton* blocks, of which about 325,000 cubic yards only have been used. At the present rate of progress the canal itself will be finished in little more than a year, with a waterway 328 feet wide and 26 feet deep.* Apropos of harbor works on the Mediterranean, it may be added that there is a scheme to greatly extend the port of Marseilles. A paper, read some time since at the Institution of Civil Engineers, gave a most interesting account of the existing works there, which comprise, among other things, the loftiest and possibly the finest warehouses in Europe, unless we except the magnificent corn warehouses lately completed at Liverpool and at Birkenhead.

Growth of Philadelphia.—During 11 months in 1868, there were erected in Philadelphia 4,706 new buildings, and 1,173 buildings received alterations and additions. This city now contains above 800,000 inhabitants.

---

* See article on the Suez Canal on another page.

Protection of Large Buildings from Lightning.—This subject has been reported upon by M. Pouillet before the Paris Academy of Sciences. The "Engineer" gives a lengthened account of it. The first thing to be done is to establish a conductor, formed of square iron measuring four-fifths of an inch on the side, which shall pass without interruption over every portion of the building to be protected; when the line is broken by towers, pavilions, or other erections, the conductor must pass up and down each, so as not to interrupt its course. This main conductor, of course, is modelled, as it were, to the form of the building, and often consists of several branches, particularly in the case of edifices like the Louvre, where there are several blocks of buildings perpendicular and parallel to each other; it will also have many minor branches, for it must be placed in good communication with all the gutters, leads, and other large metallic surfaces on the roof. This great conductor or circuit must be placed in direct communication with a body of water, which is never wanting. Ten or a dozen wells might be dug to receive each a conductor leading from the main circuit. Each lightning-rod must be placed in perfect communication with the main circuit.

Cement to Resist Red Heat and Boiling Water.—To 4 or 5 parts of clay thoroughly dried and pulverized, add 2 parts of fine iron filings free from oxide, 1 part of peroxide of manganese, one-half of sea-salt, and one-half of borax. Mingle thoroughly, and render as fine as possible, then reduce to a thick paste with the necessary quantity of water, mixing thoroughly well. It must be used immediately. After application it should be exposed to warmth, gradually increasing almost to white heat. This cement is very hard, and presents complete resistance alike to red heat and boiling water.

Another Cement.—To equal parts of sifted peroxide of manganese and well pulverized zinc white, add a sufficient quantity of commercial soluble glass to form a thin paste. This mixture, when used immediately, forms a cement quite equal in hardness and resistance to that obtained by the first method.—*Blätter für Gewerbe.*

PUBLIC BUILDINGS.

HOSPITALS—THEIR REQUIREMENTS, ARRANGEMENT, AND VENTILATION.

Condensed from a paper before the Architectural Association by T. R. Smith, F. R. I. B. A., and from the ensuing discussion.

Hospitals are peculiarly a modern institution. While examples of many classes of structures suited to our modern ways, such as, for instance, houses, baths, theatres, and churches, abound in the remains of classic times, there are no Greek and Roman hospitals. The simple infirmary of a monastery is no example to us as to *scale;* and the vast establishments of the 16th and 17th centuries are not very valuable specimens of arrangement and detail.

When we remember the great cost and disturbance of domestic arrangements necessary to provide suitable air, light, quiet, medicine, food, and attendance to the sick in our houses, and reflect that the poor, and even the majority of the people, cannot provide nor afford these facilities, the necessity for *many* hospitals and of *good* hospitals with all these facilities that make the difference between life and death to so many of our fellow-creatures, becomes obvious.*

At the same time, so good an opportunity of studying disease is not to be neglected. Where some hundreds of sick are always collected, there the students of sickness and how to cure it ought to be, and in fact are found.

What a Hospital Must Provide for.—We have now the elements for understanding this question.

First. The inmates, or in-patients, that is, the sick who reside and are treated in the house. The rooms they live in are technically termed wards.

Secondly. The administration. This embraces medical officers, dressers, sisters, nurses, attendants, and the parts of the building appropriated to their use, and to cooking, stores, business offices, etc.

Thirdly. Out-patients. Those who come to the hospital periodically for advice and medicine, and the portions of the building where they are received, seen, and supplied.

Fourthly. The Medical School, that is, students and professors, and their lecture rooms, library, museum, dissecting room, etc., etc.

Requirements of Wards.—The most important part of a hospital is the wards. For economy of attendance it is practically found best to place from 20 to 30 beds in a ward; reserving, however, a few small wards where only 2 or 3 beds are receivable for special cases.

The most important provision for the sick which the architect can make in a hospital, is a supply of plenty of fresh air. This is the one consideration to which all others ought to give way. The patient ought to have plenty of air in his ward, and that air ought to be constantly renewed. This, according to all authorities, will promote his recovery more than any one thing, and will prevent his injuring his fellow-sufferers. Many diseases are directly communicable by atmosphere, and surgical cases vitiate the air of the room. The best authorities consider that each bed should have from 1,500 to 2,000 cubic feet of air space, and that the change of air, while, of course, not sufficiently rapid to create a draft or a breeze, should yet be sufficient to be felt as an air passing over the face and hands. The sick must not be so placed that the air to reach any bed must necessarily pass over any other, they must not be too many in one room; there must not be too many wards under one roof, nor too many stories of sick one above another, nor too ready access from one ward to another. And there must be clear passages between the beds and up and down the ward.

Next to air, light and cheerfulness are conducive to health. All these requirements are practically best met by wards that are long in proportion to their width, arranged so that one of the long sides shall have an aspect exactly or nearly south, with a row of beds at each side, placed with their heads to the wall, and a row of windows on each side. A width of over 20 feet, and under 30, averaging 25 feet, is the most useful; over 30 feet the ventilation becomes sluggish. Beds ought to be about 8 feet apart from centre to centre, and the height of the ward ought to be at least 15 feet. No bed should come in front of a window. A window to each 2 beds is the usual allowance, and the windows ought to go as

* Even in the large English schools it has been determined to make the hospitals in one ward, rather than in separate rooms.

nearly as possible to the ceiling, and to come down low enough for patients in bed to be able to look out of them.

VENTILATION is a subject upon which authorities in all countries differ. The best known and most followed English plan is having windows facing each other on the two sides of each ward, and keeping them almost constantly open. This is termed natural ventilation. For this purpose windows may be sash windows in several heights; often, however, they have in their height several casements, each hung at the bottom edge, and capable of opening back at the top, so that the incoming air shall be thrown upwards. These casements ought to be capable of being regulated with great nicety, and made to remain at whatever angle they are set. They should be glazed with thick plate glass to diminish the loss of heat that occurs at all window openings; or, better still, double glass, with perforated zinc, taking the place of some of the panes of glass.

But there is in this apparatus the means of killing patients as well as curing them; especially in a climate like ours. Window ventilation, especially where not tempered by wire gauze or perforated zinc, is often the cause of fatal or dangerous relapses. Patients suffering from kidney disease, bronchitis, or rheumatic fever, are certain to relapse if they get a chill. A greater degree of care is required where there are many surgical cases. The belief is therefore spreading, that an appliance for keeping up a supply of fresh air, warmed and moistened, and for drawing off foul air, ought to form part of a hospital ward, and ought to be equal to keeping the wards thoroughly aired in frosty or stormy weather, at night, or at any other time, when windows cannot be safely open.

In the warming and ventilation of the new St. Thomas's Hospital, in each ward there will be 3 open fire-places on the centre of the floor,* with a vertical tubular flue from each passing up to the ceiling, having an outer air-tube round. This will serve to carry off some of the vitiated air beyond what goes up the flue with the smoke. The architect has also supplied 4 foul air extraction flues, which meet in the roofs, and near the outlet of which a current is kept up by a coil of hot-water pipes, which will be always at work, as they are part of the system for supplying hot water night and day to each ward. As an auxiliary for cold weather, coils are introduced on the floor, and the boiler for working them is a separate one. Air inlets exist in the floor. These arrangements are quite distinct and disconnected for the different pavilions as though they were distinct buildings.

There are hospitals with ward windows at the ends only, or merely along one side, and one row of beds down the centre, or even double rows with an open arcade between them like the nave and aisle of a church. But the knowledge has been slowly and painfully obtained, that these forms of wards are all, for this climate at least, a mistake, for the reason solely that they are found more difficult to ventilate, and there seems no reason to believe that any material alteration will be made in the dimensions, proportions, or arrangement of a hospital ward, till we have first established, if ever it can be done, a perfect system of hospital ventilation.

PROVISION AGAINST INFECTION.—The ward ought to be so fitted and finished as to harbor neither vermin nor infection. Wall paper and wooden skirtings must be dispensed with. Ordinary plaster is porous, so is soft wood; common floors and walls are therefore liable to absorb insidious poisons. The floors, accordingly, ought to be of the hardest wood, such as oak, not tile, which is chilly to the feet, and ought then to be rubbed with beeswax and oil till all the pores are filled up, and the surface is smooth and hard, or else oiled and lacquered, as is the fashion in Berlin. The walls and ceilings ought to be of the hardest obtainable material, Parian cement being recommended as having the best surface for the purpose.

HEATING.—For the heating of hospital wards, English authorities concur in recommending open fires. The French frequently warm their hospitals as they do other public buildings, by a hot-air apparatus, and must thereby run a risk of diminishing the advantage of their excellent arrangements in other respects.

THE BUILDINGS ATTACHED TO THE WARD

* To prevent these fires from heating the nearest beds too much, the openings to the fire-places are made to look up and down the hall or ward.

should be as follows: The head nurse of each large ward requires a separate room with a window looking into the ward. A smaller room called a ward scullery is also required with a fire-place, hot and cold water, and a sink. At the opposite extremity of the ward are required a group of closets, and one or more baths, and a lavatory. The arrangement of the closets is most important; not only should each have direct ventilation, but there should be a cross-current of air traversing the passage between the ward and the closets, in order, if possible, to prevent effluvium from coming into the ward. There ought not to be fewer closets than 1 to every 10 patients. Somewhere near the ward, but not in it, there ought to be a small lift, on which the patient's food, technically termed the diets, is brought up from the kitchen corridor, and it is usual to provide both a dust shaft and a foul linen shaft, from outside each ward to the basement. A large lift, capable of taking a patient and his bed and an attendant, ought also to be provided in each block of wards.

These, and no other rooms, ought to be appended to each ward. Convalescent rooms where they are introduced ought to be elsewhere.

The Series of Wards.—How are they to be arranged so as to make one large institution? From considerations of economy, especially in cities, we place them one above another; but this soon reaches a limit, and is objected to entirely by Miss Nightingale and others. It is agreed on all hands, that it is advisable not to put the sick into a story exactly on the level of the ground floor.

The modes in which wards have been arranged are very various, but there appears to be a general feeling that the best possible way has been now found out. Where only two wards on a floor constitute the hospital they are well arranged in a continuous line with a staircase in the middle; where a larger number of wards has to be provided on each story, they would now be arranged parallel to each other (so that all can have a sunny aspect), and at a very considerable distance apart. This is called the pavilion plan, or block system. Each pavilion is in fact the ward, with its appendages repeated as many times as there are to be stories, and has its own independent staircase. It is isolated from its neighbors by a space which ought to be enough to keep it almost all day clear of the shadow of adjoining pavilions, affording its windows all the air and sun they require, and it is connected to its fellows by a corridor on the lowest story only. A usual plan is to make these pavilions occupy two sides of a hollow square. The best known example is one of the Paris Hospitals, the Lariboisière.*

Other Departments and Buildings.—The principal entrance for in-patients, leading to a receiving room, should be well marked and readily accessible.

The out-patients require a simple but spacious and well-ventilated waiting room, with a separate entrance and vestibule. The adjoining physicians' and surgeons' rooms should also adjoin each other, and should have a good light. A dispensary for receiving prescriptions and issuing medicines through a window should be convenient to the waiting room. All these rooms should have closets. A casualty ward where persons not seriously injured may be attended to, should form a part of this department.

An operating room (a theatre in large hospitals) should be accessible to the various wards. It should have a northerly top light, and connect with a surgeon's room, and a small ward for patients who cannot at once be removed after operations.

The dissecting room should be lighted from the top, and specially well ventilated. It should adjoin a dead-house.

Rooms for the physicians and surgeons, and residences for other officers and attendants, should communicate with a corridor leading directly to the interior of the hospital. The number of personal attendants on the sick is, in the best hospitals, one to every seven or eight patients.

The kitchen should be removed from immediate contact with the wards and ordinary entrances, and yet should be accessible to marketmen and tradesmen. It should be surrounded by the necessary stores and offices, and should have a wine cellar and ice-house. At the same time it must be central, so that the "diets"

* This, and several of the best modern hospitals, are illustrated in the "Civil Engineer and Architect's Journal," May, 1858.

(cooked rations) may be quickly carried to the various wards by lifts.

Linen, bedding, and bandages require a separate department. So does the laundry.

In arranging these separate departments, one rule should especially be followed—that whatever goes into them should pass in a direct course from one end to the other, without being shifted back and forth.

A Medical School, in addition to bedside or clinical lectures, should usually be attached to large hospitals, and should consist of lecture rooms, rooms for experiments and preparations, professors' rooms, a library, and a museum.

SITES.—As to sites for hospitals, Miss Nightingale says unhesitatingly that they ought all to be in the country. Certain it is that a pure air and plenty of space are the most important of all conditions of recovery. The arguments against the country are—first, that such sites are out of reach of patients; secondly, that they are out of reach of doctors; and lastly, that they are out of reach of students. The site must be spacious, airy, dry, sunny. It should not if possible be in an overcrowded neighborhood, or with any nuisance near. A gravelly soil is preferable, and a sufficiently high elevation. A bed of concrete over the whole site is recommended as a good preventive against moisture; this has been done at St. Thomas's.

NEW SYSTEM OF SCIENTIFIC EDUCATION.

A new system of high scientific education has been adopted in the government schools of France. The following abstract of the system is from the Paris correspondence of the "Engineer":

The new scheme, which is founded on Imperial decrees only a very few weeks old, includes not only laboratories of education and of research, but also the creation of a practical high school or college of science (*Ecole Pratique de Hautes Etudes*). The main idea of the plan is bold, simple, and sensible, namely, the making the present educational staff and establishments available for the new institution. With the view to carry it out, the Government has introduced into its budget an augmentation of the salaries of professors in the superior schools and colleges, to come into operation from the year 1869, in recompense for the additional labor which will be demanded of them in giving class lectures in addition to their present public ones.

The new laboratories will be of two kinds, one for instruction the other for research, the former being as it were nurseries for, and supplying the professors with assistants for the latter. Such laboratories of research, of which three or four already exist in Paris, have, says the Minister, "enabled Germany to arrive at that great development of experimental science which we watch with so much uneasy sympathy."

The new school is not to be essentially a professional school, but a college for improvement. "The young man," says the report, "who feels within him the sacred flame at which, perhaps, genius may light its torch; he who has completed his general studies, or the spirit of which may be repugnant to him; he who is not tempted by the hopes of a lucrative calling, or who may be irresistibly attracted from a profession already acquired towards pure science, does not find in our present establishments all the means necessary to help him rapidly and surely to the object of his vocation." Besides books, collections, and general lectures, he wants precise directions, general council, or support, and the means of verifying by observation and experiment the facts which he has acquired. "Able professors," says the report, "often discover peculiar bents or capacities in their pupils, and in the case of chemistry during the last thirty years much has been done in the way of superior education, and the rank of France in the world of science has greatly benefited thereby. The object now is to supply the other branches of science with schools like that which has done so much for this science." The word "practical" must not be taken in its ordinary signification of industrial utility, but in the higher sense and as indicating that the eyes and hands require to be called into use to strengthen and extend the most delicate and highest conceptions of the scientific spirit. What are chemistry without manipulations, physics and physiology without experiments, or botany without herballising?"

The school is to be divided into four

sections, entitled:—Mathematics, physics and chemistry; natural history and physiology; and historical and philological science; and to these may be added hereafter a section for juridical studies. Of course a pupil may belong to all or several of the sections.

The school is open to all the world, without any limit as regards age, grade, or nationality, but all pupils must undergo a preliminary stage of three months or less, at the termination of which the director makes a report; they are then examined by a permanent commission which sends up a list to the Minister, with whom alone rests their nomination to the school. Pupils can only remain 3 years on the school list. All the private lectures and normal lessons of the professors are open to them as well as the laboratories of instruction; they are bound to furnish written essays, *précis*, and analyses on given subjects and works published in France or abroad, and to make researches in the libraries and museums on set subjects, and to report results in writing; and the pupils in the natural history section will take part in scientific excursions under the direction of the professors. No mention is made of fees, so that the education appears to be perfectly gratis; and moreover the Minister may, upon the recommendation of the superior council, allow an annual indemnity to the pupils of the school. The directors of the laboratories have also the power of recommending pupils who show great aptitude as their assistants, and the Minister has the power of awarding them indemnities. Each section of the school is placed under a commission of five members nominated for three years by the Minister of Public Instruction, and chosen by him from the list of directors of laboratories and studies, as the professors of the school are called. The directors of the laboratories and of studies will grant certificates to their pupils, and make annual reports to the commission, and after examination of these reports by the superior council the Minister will entrust successful pupils with missions and award medals, honorable mentions, subventions, or special recompenses.

The organization of the new school extends to the provinces, the directors of laboratories and studies connected with scientific establishments in the departments as well as the pupils to enjoy the same privileges as those of Paris.

LIQUIDS FOR HARDENING STEEL—TEMPERING COLORS.

From a new Treatise on Steel, translated from the French of M. H. C. Laudrin Jr., by A. A. Fesquet. Philadelphia, Henry Carey Baird, 1867.

Notwithstanding what has been said, and the so-called experience of some practical metallurgists, pure water is the best liquid for hardening steel. It is a mistake to believe, with the ancients, that certain waters are more adapted to this operation than others. The only difference lies in their temperature. A workman of Caen, M. Damesme, who has published a diffuse work on steel, has tried the hardening of steel in the juices of vegetables, and has ascertained that there is comparatively no advantage over hardening in water. Mercury has no other property than that of being cold, and of producing a hardness which can be obtained with water at the same temperature.

Tallow and oils, where carbon is one of the constituent elements, produce an imperfect hardening, but prevent a loss of carbon. When by overheating, steel has been burned and decarburized, the oils and fatty matters are useful, because they give back to the steel a part of the carbon lost in the fire. Some acids, such as sulphuric, are justly considered as imparting more hardness to steel, by dissolving a film of iron from the surface and exposing the carbon. As for urine, alcohol, brandy, and a thousand other liquids extolled by ignorant workmen, they are not worth as much as water, which has the advantage of being abundant everywhere, cheap, and adapted to all changes of temperature.

Some workmen heat the steel which is to be hardened, much above a cherry redness, allow it to cool slowly in the air, and wait until it has taken a certain color, previous to plunging it in water. This is a very bad practice, because by an excess of heat there is a loss of carbon, and an alteration of the steel, which has then large grains, and is without tenacity at the edges.

After hardening, the temper or hardness is drawn as required for different

purposes by reheating—the color of the steel being the guide.

1. Being put upon burning fuel, the steel gradually heated becomes tarnished, yellow, and *straw yellow.*

2. The heat increasing, the color deepens, and reaches a gold yellow, *full yellow.*

3. Afterwards, the steel takes several shades, rapidly following and blending with each other; they are purple, pigeon's throat, copper, *brown purple.*

4. These shades become deeper until they become *violet.*

5. Afterwards, they pass rapidly to indigo blue, *full blue, dark blue.*

6. This color becomes weaker, and gives a *sky blue* more or less pure.

7. The blue takes a greenish tint and produces shades which are gray and *sea-green.*

8. At last, the steel *reddens,* and will no longer give distinct colors.

The shades of these eight colors, which are called tempering colors, and perfectly distinct, very apparent, and easy to recognize; but they take place only after hardening and on clean steal. The metal which has not been hardened, will not show these colors so plainly; the shades are mingled, blended, and less in number.

The colors, during the tempering, are a sure guide for the workman, of the degree of hardness or tenacity he desires to obtain. Dark blue indicates a great tenacity, straw yellow produces a greater hardness, and is the tempering shade for razors. Bistouries, lancets, penknives, erasing knives, some scissors, and generally blades requiring body, are reheated to full yellow. The strong blades for table knives and gardening tools are tempered to a brown or purple brown. Purple is the proper color for large shears. Violet and dark blue are for springs; with a violet color, the spring will be very elastic but brittle, a blue shade will make it very resisting. It is very difficult to break a spring reheated to the color of water; but its elasticity is a great deal lessened.

The hardened instruments are reheated in or upon a live fire, easily regulated, and without the help of bellows as far as practicable. An intelligent workman will cease blowing as soon as he perceives that the metal begins to change its color. The proper shade must come by itself without increasing the fire, and must be regular all over, before the piece is plunged in cold water. Sometimes this last dipping is omitted.

The small pieces, such as penknives, erasing knives, etc., rest upon a wire cloth put into the middle of the fire; when they have reached the proper color they are cooled in water.

A lancet requires a special tempering; the shank must be blue; from there the color will be first purple, next brown, and at the point, full yellow. These various shades upon one blade are a necessity, on account of the degree of hardness and tenacity required by this instrument. Full yellow will produce the proper sharpness, but would not be suitable to the rest of the blade, which, instead of hardness, must have tenacity and elasticity.

A good workman, willing to give the greatest perfection to an instrument, will be very careful when tempering it, in order to obtain the various shades which are necessary. A knife, for instance, must be brown purple at the cutting edge, purple in the middle, and sea green at the back, to unite the hardness of the cutting edge, with a certain amount of resistance which will prevent its breaking under a strain.

This is obtained by using certain precautions, and above all, by not going beyond the proper degree, because it is very difficult to retrace the steps. If the fire was too strong or irregular, part of the edge may be purple brown, while the other is only straw yellow; then, by pinching the blade between red-hot tongues, at the place which should be more heated, the temperature rises rapidly, and the instrument is brought up to the proper tempering point. Certain scraping and burnishing tools, and steels for sharpening, do not require any tempering, because they cannot be too hard.

THE RHODE ISLAND LOCOMOTIVE WORKS are making 5 locomotives a month, and their capacity is to be doubled.

LEAD PENCILS, once really made of lead, are now chiefly made of the plumbago from the Alibert mines in Siberia.

ELECTRIC LIGHTS FOR LIGHT-HOUSES AND SHIPS.

By Ernest Saint Edme, of the Conservatory of Arts and Trades.

Translated from *Annales du Génie Civil*, September, 1868.

The Electric Light is nothing but the luminous arc formed between two carbon points fixed at the poles of a strong pile, or magneto-electric machine. It is due not to the combustion of the carbon points, but to the irradiation of their molecules, which fly continuously from the positive to the negative pole of the source of electricity. Hence, were there no combustion, that is, were the operation in a vacuum, the distance between the points being regulated according to the intensity of the current, there would be a continuous luminous arc, since the exact quantity of matter forming from the positive would arrive at the negative pole.

The function of a *regulator* of the electric light is, therefore, to correct mechanically the space between the carbon points, which results from their combustion, in air. The operation cannot be in a vacuum, for the glass envelopes cannot resist the heat due to the formation of the arc. Messieurs Staite and Petrie in England, and Léon Foucault in France, solved at the same time the question of photo-electric regulators; and to Foucault is due the first idea to make the electric current itself regulate the movement of the points. Since the first attempts to apply magneto-electric machines to produce light, the regulators exclusively used were the well-known ones of J. Dubosc, disposed to utilize the continuous currents; but the conditions of the apparatus were such that they could work with intermittent currents. A little later, when the regulator of Mons. Serren was coming into use, Mons. Joseph von Malderen, during a discussion, inquired of him whether he could overcome some of the defects of Dubosc's lamp; and he found that the principle of Serren's regulator was such that it could work with currents uncorrected. Thus it was a lucky chance that led to the discovery that the regulator of Serren, constructed like all others to be used with currents from the pile, could work with the uncorrected currents of the machines; but that which had no chance about it was the intelligence and perseverance of Malderen, who comprehended that the difficulty came from the regulator; and that what one failed in, the other might perhaps accomplish.

Since then, each inventor had to transform his apparatus; and Foucault, just before his death in 1866, gave the last touch to one of his early models, and confided to Dubosc the task of realizing his idea. Serren's regulator was applied in the light-house at Cape la Hève, and Foucault's in the garden of the Exhibition. The latter excited doubts on account of the great precision required in fitting; but a trial of long duration proved the genius of its author, and his ability to reconcile delicacy and complexity with solidity.

Foucault undertook to make a regulator that should absolutely fulfil the two main conditions—the diminution of all the causes of extinguishment, and the fixity of the luminous point. The two principal causes of extinguishment are: the too great separation of the carbon points, and their accidental contact.

[The description of the apparatus would be scarcely intelligible without the engravings, which we have not time to prepare for this number; we therefore must refer those who are specially interested in the details to the *Annales du Génie Civil*, for September, 1868.]

This regulator, constructed by Dubosc, has since been arranged by him to work either with the pile or the magneto-electric machine, with the precision required; and it is sufficiently hardy for service in light-houses, ships, and operations under deep water.

Mons. Reynaud, director of the administration of light-houses, three years ago, made a complete report on the question of electric lighting on the coasts; and since then nothing of interest has appeared to add to that report. The following tables taken from it show that the cost of lighting by oil is dearer than by electricity, in the proportion of 580 to 79.

Light-house with Oil Light.

	Francs.
Apparatus, with armature	37,940
Mechanical lamps, 3	2,100
Revolving machine	3,200
Furniture	900
Lantern, with glass, etc.	20,400
Setting up	3,900
	68,440

Annual cost for 4,000 *hours of lighting.*

	Francs.
Interest and wear, 10 per cent.....	6,844
Annual expenses.....	7,973
	14,817

Which, divided by 4,000, gives 3.7 as the cost per hour.

The intensity of the light sent to the horizon, is about equal to 630 Carcel burners: the cost per unit of light equal to that of a Carcel burner, is therefore .58 francs.

Light-house with Electric Light.

	Francs.
2 magneto-electric machines.....	16,000
2 steam engines and accessories....	6,000
2 regulators and setting up.....	3,000
Lenticular apparatus.....	3,000
	28,000

Cost per hour for 4,000 *hours per year.*

	Francs.
Interest and wear.....	.70
Fuel for steam engines.....	.40
Wages for 2 firemen.....	.70
Wages for 2 watchmen.....	.50
Carbon crayons.....	.36
Oil, etc., for machinery.....	.13
	2.79

The mean intensity of the light sent towards the horizon, that is, taken outside of the apparatus, is equal to 3,500 Carcel burners, which gives as the cost of a Carcel unit of light sent to the horizon, $\frac{2.79}{3500}$ = .079 francs.

Against this immense advantage in favor of electric light there is the fact that the light from oil has more power to penetrate fog, being richer in red rays, than the electric light. In misty evenings one can see that the moon and gas lights have a red or orange tint, the blue rays being refracted, and unable to traverse the foggy atmosphere. Therefore, to make the electric lighting sure, it is necessary to have 2 machines, one of which will be kept ready for use in case of accident to the other; or in case of fog, when both will work together, and give double light. In this way the greater atmospheric resistance is overcome. This expedient is not possible with oil lamps; for we cannot double the flame of a lamp as we can double the electric current that flows between the carbon points.

Electric lighting in light-houses seems not to have made much progress since the report Mons. Reynaud; and the reasons of it are easy to be seen.

To transform existing light-houses, we must sacrifice the existing apparatus, for the sole advantage of increasing the light at any moment. Besides, it is doubtful whether all light-houses are large and strong enough for the accommodation of the new machinery; this is certainly the case with most of the light-houses on the coast. As to the light-houses of inferior order, it would be illusory to think of altering them. And other difficulties are inherent in electric lamps, which, however well designed, are subject to causes of derangement which render necessary the best mechanism; and the crayons, if impure, may scale, and cause interruptions; and these impurities might cause mistakes incompatible with the service of the light-house.

In conclusion, when a new light-house is to be built, it will be advantageous to adopt the electric light; but the importance of the question, relative to the general administration of light-houses, is much less than was at first supposed.

In 1863, in a notice of the applications of the electric light, we suggested the lighting of vessels by it. The maritime exhibition at Havre shows that our suggestion has been considered, at least in principle. In the point of view of lighting the course of a ship, no one will deny that the oil lantern is insufficient to prevent collisions at night; while the electric lantern would illumine the air all around, and the rocking of the vessel would cause such changes of light as would attract the notice of the men on other vessels. When we consider the whole cost of a ship, that of electric engines is insignificant; 2 or 3 horse-power will work a magneto-electric machine. And the electric light will serve other purposes on board a ship. Recent experiments have shown that it would be possible to assist a ship in her course by dazzling the steersman by a jet of light, when an oil lantern would not be seen by him.

It can also be used to light under water; an application that concerns the repairs of the sheathing and hulls of vessels, the finding of lost articles, and the catch-

ing of fish. The fish are confused by the light, and then easily caught. Mons. Dubosc exhibits a specimen lantern well fitted to enclose an electric lamp. The conducting wires are connected so that there is no chance for water to leak into the lantern. This apparatus can, without fear of too high pressure, be lowered to great depth in the sea.

View from a Balloon.—The view over London, in ascending 2,000 feet, is thus described by the "London News":—The earth and its dwelling-places, its trees, its roads, its rivers, drop slowly down and resolve themselves into a clearly defined, widely spreading map. The steamers plying on the Thames recalled the toy-boats at the Polytechnic; the black ants rushing busily to and fro in the barren space immediately below were schoolboys in a playground a few minutes since; the strips of drab tape stretching their devious courses to right and left are roads; the squares and oblong green patches with dark borders, fields; and that large table upon which a game of dominoes is apparently being played is Brompton Cemetery; and it is its profusion of white tombstones, some flat, some upright, which are recalling the old game. There seems a mighty stir among the pigmies below, and huzzahs which become faint in the distance, but are never quite lost, come up to us cheerily. The small boxes drawn by ants, into which cabs and omnibuses have resolved themselves, twine their way along the strips of drab tape, and almost arouse wonder by never deviating from their path.

Sulphocyanide of Ammonium.—At the last meeting of the British Association, Dr. Phipson read a paper on this subject, in which he pointed out a fact of some importance to agriculturists, viz.: that for many years past the ordinary sulphate of ammonia manufactured in gas works by neutralizing gas liquor with sulphuric acid contained small quantities of sulphocyanide of ammonium, say from 2 per cent. to 4 per cent.; but latterly many specimens of commercial sulphate of ammonia contained a very much larger proportion, some specimens yielding as much as even 75 per cent. of sulphocyanide. So that, in fact, the article might rather be named impure sulphocyanide of ammonium than sulphate of ammonia. The knowledge of this fact is of great importance to makers of chemical manures and farmers, inasmuch as only one-half of the nitrogen existing in sulphocyanide can be made available for manuring purposes.

Chemical Nature of Cast-Iron.—At the last meeting of the British Association the report on this subject by Dr. Matthiessen and Dr. Russell led to some discussion. It seems that though no less than 70 experiments were made in the production of pure metallic iron from its various compounds, the reporters had not yet succeeded in obtaining any iron perfectly free from sulphur. Dr. Mathiessen hoped, however, by continuing his researches, yet to obtain a perfectly pure sample of metallic iron. In the course of the discussion which followed, Mr. Sutton suggested that probably the presence of sulphur in iron was only another instance of the persistence of that element in the atmosphere, as shown by the experiments of Mr. W. F. Barrett, who first devised the method of detecting the presence of sulphur upon the surfaces of bodies exposed to the air by projecting upon them a flame of hydrogen, a magnificent blue flame resulting therefrom.

Boiler Explosions, having been attributed, from time to time, to every known agency of explosions, it is not singular that upon the discovery of nitroglycerine, they should have been attributed to it—upon the following curious reasoning: Fatty matter in the water in a boiler, acts chemically on the steam, forming glycerine. When organic matter is present in the water, the chemical affinities will set free electricity, which generates ammonia—which mixed with moist air at a temperature 212° Fah. over water containing potash, produces the nitrate of potash. Glycerine and nitric acid readily combine chemically, the glycerine gives up a portion of its hydrogen and takes on a part of the oxygen, when they all combine into a new compound, nitro-glycerine, which has 2½ times the specific gravity of water. Nobel's blasting oil is composed of glycerine, sulphuric acid, and the nitrate

of potash. Nitro-glycerine being insoluble in water, and having greater specific gravity, it readily finds the bottom of the boiler, where it would remain were it not for the sudden rise of temperature. It is not explosive at 212° Fah., but at 360° Fah. (which it soon attains in contact with the boiler plate), explodes with 13 times the force of gunpowder. Hence those terrific and unaccountable explosions that so often take place when the boiler contains its maximum of water. Finally, at least 90 per cent. of all the terrific disasters on our western rivers have occurred in the spring of the year, when the rivers were full of surface water containing organic matter, fats or oils, potash, and sulphur; or they blew up at or near the levee of some city, where they had taken on a supply of water contaminated with sewerage, containing the very elements of destruction.

As the *Scientific American* suggests, all the elements of gunpowder also exist in river water, and gunpowder is, therefore, as likely a cause of boiler explosions as nitro-glycerine.

AN ENGLISH EXPRESS LOCOMOTIVE.

The following are the principal dimensions of the latest style of passenger engine on the Great Northern Railway. The engine has a pair of leading and a pair of trailing wheels, a pair of drivers nearly in the centre, and inside cylinders —the old-fashioned English engine, without modern improvements in the distribution of weight and strain, but well-proportioned in detail:

	Ft.	in.
Boiler:		
Diameter of barrel, inside smallest plate	3	9⅛
" " " largest "	3	11⅛
Length of barrel	10	2
Length of inside firebox	4	8¾
Width " "	3	5
Height " " at front	5	9⅛
" " " at back	5	3⅛
Thickness of barrel	0	0⅛
Thickness of smokebox tube plate	0	0⅝
Thickness of firebox plates ⅜ in., except tube plates, which is ⅝ in. thick at the upper part, and thinned to ⅜ in. below the tubes.		
Number of tubes, 192.		
Length " between tube-plates	10	5⅜
Diameter " outside	0	1¾
Thickness " at firebox end No. 12 W.G.		
" " " " " 14 "		
Length of smokebox inside	2	5½
Diameter of chimney inside at top	1	6¾
" " " at bottom	1	0¾
Height of chimney above top of smokebox	3	10

Heating surface:		
Tubes (outside)	922¼	square feet.
Firebox	89¼	"
Total	1011½	
Firegrate area	16.4	square feet.
Wheels and Axles:		
Diameter of driving wheels	7	1
" leading "	4	1
" trailing "	4	1
Distance between centres of leading and driving wheels	9	6
Distance between centres of driving and trailing wheels	7	6
Total wheel-base	17	0
Bearings of Driving Axles:		
Diameter	0	7
Length	0	7
Bearings of Leading and Trailing Axles:		
Diameter	0	5
Length	0	10
Diameter of axles at centre	0	5
Cylinders:		
Diameter	1	5
Stroke	2	0
Length of ports	1	2
Width of steam ports	0	1⅛
" exhaust ports	0	2⅛
Working Gear:		
Length of connecting-rods between centres	5	9
Diameter of bearing at large end	0	7
Length " " "	0	4
Diameter " small "	0	3
Length " " "	0	3
Width of guide bars (double)	0	2⅛
Length of crosshead blocks	0	10
Diameter of piston-rods	0	2⅝
" valve spindles	0	1⅝
Length of eccentric rods between centres	5	2⅛
Frames:		
Length of frames outside buffer-plates	23	4
Thickness of inside frames	0	1⅛
" outside "	0	0⅞
Depth of inside frames between cylinders and driving horn-plates	1	5
Depth of inside frames between driving and trailing horn-plates	1	3
Depth of outside frame between horn-plates	1	0

Weight of Engine Empty:

	tons.	cwt.
On leading wheels	9	13
On driving wheels	12	12
On trailing wheels	8	0
	30	5

The steam pressure carried is 130 pounds; the tractive force about 7,000 pounds; the regular speed 44 miles per hour, exclusive of stops. The tyres, axle-box guides, crank axle, guide bars, and piston-rods are of steel. The engine is fully illustrated in "Engineering," Oct. 9.

THE PHŒNIX MILLS, at Seneca Falls, N. Y., are the largest of their kind in this State. They comprise 3 buildings of the following dimensions: 200 by 70 feet, 150 by 50, and 120 by 65, with a warehouse 200 by 45, They contain 26 sets of woollen machinery of the most improved patterns. The working force of the mills is 1,000 hands.

OLD AND NEW WAYS OF BREAD-MAKING.

From the "American Artisan."

There is probably no substance used for food that has been made from a greater diversity of materials or by a greater variety of ways than bread, and very few which possess greater elements of interest to the general reader or the student of practical science.

It is believed that the earliest loaves were made at a period anterior to the invention of even the oldest grinding or pulverizing devices, by simply soaking grain in water until it became soft and pulpy and then pressing it into cakes, which were baked in the camp-fire embers where the rude and wandering tribes pitched their tents each night. It was but a slight advance on this to bray or pound the wheat, millet, or other grain in a mortar, and, after moistening the powdered mass, spreading it upon a hot surface to bake, or placing it wrapped in leaves in the hot ashes for the same purpose; yet this, almost the first and primitive method of bread-making, has obtained, with a simple change in the mode of pulverizing, to this day. When the Hebrews dwelt in the land of Goshen they baked the *huggoth*, or little cakes of unleavened bread, under the ashes or upon the hearth. In recent times the far-famed oat-cakes of Scotland have been made by wetting the coarsely bruised or powdered oats with water having a little salt dissolved therein, and after rolling the mass into a thin sheet placing it before the fire. Bannocks are said to be made in the same way in India, and in our own country bruised corn-meal spread wet upon a shingle, placed aslant in front of the hearthstone fire, constituted the johnny-cake that made the greater part of the pioneer's daily fare. The method of baking under the ashes is still followed by the women in Bulgaria when bread must be made in haste, so as to meet the wants of travellers; and the hoe-cake of the South owes its charcoal crust to the same process. The making of bread is also characterized by the unique nature of the materials used; for instance, the Laplanders, having no grain, make a kind of bread of dried and pulverized fishes and the inner bark of the pine-tree, and in Sweden and Norway the wood of beech and similar trees which contain no turpentine is sometimes converted into bread. This is done by macerating the wood in water, and boiling it to remove the soluble matter. The wood thus macerated, after being heated several times in a suitable oven, is reduced to a fine powder by grinding. It is asserted that this wood-flour much resembles that made from corn, having a yellowish color and being capable of fermentation on the addition of yeast, and furthermore producing loaves of uniform and spongy texture. This flour also yields by boiling in water a thick jelly something like that made from wheat-starch. Pulverized pine bark is very often mingled with rye-flour in Northern Europe.

The bread made according to the simple methods above described may all be classed as unleavened bread, but the use of barm for making raised bread was known as far back as the time of Moses; and its employment passed from Egypt to Greece and Italy, and afterwards to all the northern nations conquered by Roman arms. No other means of making light or raised bread were ever known until within a comparatively recent period, when the same spirit of progress that revolutionized other departments of industry led to improvements in the art and mystery of making the staff of life. A mention of some of these last may be of interest.

Aside from convenience in the process of making, one great object sought to be secured by the recent methods is to obviate the loss resulting from the fermentation produced by yeast, and which has been variously estimated at from 2 to 10 per cent. of the entire weight of flour. To effect this object the bi-carbonate of soda and hydrochloric acid have been sometimes brought into use, there being intimately incorporated with every 4 pounds of flour employed 320 grains of the powdered bi-carbonate. To the flour thus prepared is added a solution composed of 300 grains of common salt, 6½ fluid ounces of hydrochloric acid, and 35 ounces of water. The dough being kneaded is placed in the oven for baking in the ordinary manner. The acid combines with the soda of the bi-carbonate, converting it into common salt which is left in the bread, and disengages carbonic acid which puffs or swells it up in the same way that the carbonic acid liberated

by the action of leaven brings about the same end. Another plan, most frequently adopted in making rusk, gingerbread, etc., involves the use of the sesqui-carbonate of ammonia, which, when the dough is heated, is converted wholly into a gas and passes off, leaving the bread in the form of a light spongy mass.

There is also a different plan of making what is known as aërated bread, in which the dough is placed in a box, and mixed by machinery with water charged with carbonic acid. When the dough is taken from the box where it is thus mixed under pressure, the carbonic acid escapes from the water and "raises" the bread, so that by this means not only is all loss of flour prevented, but the process, instead of requiring 8 or 10 hours, as by the common mode, may be completed in 30 minutes.

TELEGRAPH ENGINEERING IN 1868.

The progress of telegraphy during the past year has not been distinguished by any remarkable invention, and generally telegraphic extensions in this country have been checked by the contemplated assumption of the telegraphs by the Government. Messrs. Siemens have projected and commenced, in connection with our North Sea cables, an extended aërial telegraph through Prussia, Russia, and Persia, to join our Indian lines at Teheran, and though rival interests are striving very hard to cry down this route in favor of submarine lines through the Mediterranean and Red Sea, we have no doubt that the known ability of the contractors, and the manifest superiority of a well-constructed land line over the uncertain durability of a submarine cable, will make this telegraph the favorite "silent highway" to the East

Immense stimulus has been given to submarine telegraphy. There are more miles of cables in construction at the present moment than at any previous period of telegraphic history, and during the past year new cables have been submerged—between Malta and Alexandria, 900 miles; between Sunderland and Denmark, 340 miles, and between Florida and Cuba, 110 miles—though this last is not yet completed, owing to the expedition running short of cable. Sir Charles Bright is now engaged in completing his difficult task. The Danish cable is remarkable for being the first cable of any length constructed with Hooper's insulated core, and 500 miles of cable of the same material are now coiled in the tanks at Henley's works, waiting submersion in the Persian Gulf. The largest submarine project of modern days, the French Atlantic cable, is making rapid strides at the gutta-percha works and at the telegraph construction works at Woolwich. It is expected to be laid in August. It consists of 3,047 miles of rope, and it will be submerged from the same ship and by the same experienced hands that were engaged over the previous cables.

During the year Professor Wheatstone received the just reward of a knighthood for his numerous and beautiful inventions in telegraphy.

The Atlantic cable broke near Newfoundland, and was readily repaired. This is the second time such an accident has occurred. Many other such accidents have happened during the year to other cables, including the Persian Gulf, the Malta and Alexandria, the Dunwich and Zandvoort, the Lowestoft and Zandvoort, the Sicilian and Algerian, etc. The maintenance of submarine cables has become an important and valuable branch of the engineering profession, and the experience of our engineers has shown that repairs to cables are practicable in all depths. Considerable confidence in such enterprises has been engendered, and the public are becoming far more liberal in their contributions towards this vast field for investment. China and Australia cannot long remain beyond the pale of the electric spark.

The all-absorbing domestic question of the day is the purchase of the telegraphs by the State. This is expected to be completed in June. The telegraphs will pass to the control of the active executive of the Post-office, and the public will be great gainers by the exchange. How the professional branch is to profit or suffer remains to be seen.—*Engineering.*

WATER-POWER in Maine, according to a State report, consists of above 2,000 different "privileges" of an aggregate of 300,000 to 600,000 horse-power.

SHIP CANAL FROM OSWEGO TO ALBANY.—It is proposed to construct a ship canal from Oswego to Albany by enlarging the Erie Canal from Albany to Oneida Lake, thence along the head of the lake and down the Oswego river. The lockage is 230 feet. With this canal, vessels loaded with grain could sail from Chicago to Liverpool by way of New York, avoiding the difficult navigation of the St. Lawrence river.

FURNITURE-MAKING IN ITALY.—The Italian cities were famous in the middle ages, but not more famous than at present, for the production of furniture and house and church decoration in wood, not only in large quantities, but of light and tasteful designs. The principal modern works of Barbetti, at Florence, employ about 100 workmen, and turn out a value of half a million dollars per annum. At Milan there are 30 smaller manufactories, employing some 250 men. The more beautiful of their productions are in carved woods and in marqueterie work, inlaid with metal and enriched with ormolu or colored stones, or miniatures and pictures in majolica. In various parts of the province of Milan this manufacture gives employment to 350 families. Here, as well as in the Venetian provinces and about Naples, much cheap as well as costly furniture is produced. At the principal works in Florence, Milan, Turin, and Naples, wood-working machines driven by steam are considerably employed.

WINANS' CIGAR STEAMSHIPS. — However opposed the principles of Messrs. Winans' construction may be to the general practice, it should appear that they have not been arrived at without long and costly preliminary experiment. The "London Times" details experiments made by Mr. Winans long since, in Baltimore, with various forms of hull and frictional surfaces, and states that Mr. Winans' plans are soon to be tested on the large scale of ocean navigation.

AUSTRALIAN COAL, equal to the English North Country coal, is worth 7s. to 9s. per ton at Sydney, the mines being 5 to 7 hours distant, near the coast.

WORKING PLANT AND APPLIANCES.

From "The Building News."

Human invention and ingenuity are ever on the stretch to keep pace with the contingencies that are daily and hourly occurring, and are the inseparable attendants of an age of reason, enlightenment, and national education. No sooner is one improvement patented and given to the public than another springs up superior to its predecessor, and after that another, and so on until man's inventive faculties are racked and the powers of imagination strained to the utmost to meet the ever-increasing demands.

Notwithstanding that the aid of machinery has been called largely into requisition in the construction of engineering and architectural works, yet many of the processes and operations still continue to be carried on by manual labor. Earthwork is still nearly universally performed by hand. The old system of laying down temporary rails, filling the "lorries," and tipping them over the "tip head," is still practised, and will be for a long period to come. Where the excavation takes the shape of a tunnel, special machines are used, as in the case of Mont Cenis, which is an example upon the largest and most successful scale that has ever been attempted. A marked improvement was visible in the construction of engines, movable cranes, and other mechanical appliances for raising loads at the recent "Exposition," in comparison with the specimens exhibited at previous international displays; they were much simpler in construction, better finished with respect to fitting and workmanship, more practical in design, less costly, and better adapted for rapid manipulation, and less likely to cause accidents and mishaps among those working them.

Except in comparatively insignificant instances, the old system of scaffoiding for house building is completely obsolete. Contrast the methods at present employed in the erection of the new mansions on the estate of the Marquis of Westminster with the more ancient system, wherein round larch and fir poles and rope lashings formed the prominent features. We replace manual labor in what might be termed the transference of materials by the agency of movable cranes running upon strong timber traverses; and in this

respect our system, as a whole, is superior to that of our French neighbors. There is no country where the erection of buildings, so far as modern inventions and conveniencies are concerned, has made so little progress as France. Notwithstanding that there is an abundance of more favorable appliances at hand, she continues to employ the ancient methods in spite of their slowness and cost.

One especial point in which there is a marked distinction between us and continental nations is in the substitution of iron for timber. Among ourselves this is now almost universal. An engineer would never dream of erecting a timber bridge except upon a scale of the most trifling character, nor, in fact, were it intended for railway traffic, would the Board of Trade sanction it. Cast and wrought-iron joists and beams are now the ordinary supports in warehouses and large buildings, to the almost entire exclusion of timber. The case is otherwise in France, where heavy balks are still employed in situations that we should now never think of their occupying. Recently iron wire has been used there with great success instead of ropes for scaffold fastenings. From very early times the Italians have been in the habit of adopting a peculiar description of scaffolding in which very short timbers are used, and the erection of which is carried on with extreme rapidity and considerable solidity. It is quite possible that if this system were modernized, and received the benefit of all the recent improvements and modifications, it might prove a very valuable one.

It might be supposed, from what has been stated respecting the substitution of iron for timber, that the trade of the carpenter had declined, and had, in fact, become merged in that of the smith. To some extent this is probably true, but not to a degree sufficient to affect the absolute earnings of the former. Permanent iron constructions of the present day demand an amount of carpenter's work for temporary purposes, far exceeding what was required for the permanent timber erections of bygone times. Let any one take a glance at the forest of piles, uprights, horizontal trussing, bracing, strutting, and centering, that obstruct the river at Blackfriars, and it will be more than sufficient to assure them that timber and carpentry still play a very considerable part in engineering and architectural structures.

Machinery has been established on the most improved system and on the most extensive scale for fashioning the timberwork intended for the interiors of houses; sawing, planing, mortising, tenoning, and all the other operations once performed solely by hand labor, are now accomplished by the agency of machines. It is rather curious that the principal railway terminus in Munich was one of the first instances abroad where all the timbers were prepared by machinery. Germany and our own country were the two foremost in availing themselves of the aid of steam power for this purpose.

The real merit of substitution of machinery for manual labor is undoubtedly due to the Americans, and in their case was a practical illustration of the old adage, "Necessity is the mother of invention." From a scarcity of manual labor, an inconvenience that all young countries suffer from, she was obliged to invent some means of accomplishing by machine power what was effected in more populous countries by hand labor. It is often said that the Americans invent, but we improve, and there is much truth in the remark. The reason is easily found, and the validity of the observation confirmed. The Americans have not the time to perfect any invention; they are daily, almost hourly, in want of it, and are compelled to utilize it before it has received that finish and those nice adjustments which in reality constitute the whole mechanical beauty of the machine. When the crude material comes to us we have leisure to examine it and it therefore receives from us that remodelling and final improvement which the urgency of the case did not admit of in the land of its birth.

Silsby's Fire Engine Works at Seneca Falls, N. Y., comprise 2 machine shops, 120 by 45, and 60 by 45, a foundry 90 by 50, a smith shop 75 by 50, a boiler shop 40 by 40, a paint shop, brass foundry, etc. They employ 160 men, and have built over 200 steam fire engines, besides various steam and pumping machines and hydraulic fittings. The Silsby pumps are rotatory instead of reciprocating.

THE IRON WORKS OF LE CREUSOT.

Condensed from the Correspondence of the "Mining Journal."

Few travellers through Burgundy, and more especially that portion of it purple in the summer's prime with the luscious fruit of the vine, would imagine that it has its black country. But a cloud of smoke persistently hangs over a portion of it—smoke from the iron works of Le Creusot, which, from the small proportions of a local forge, set up in 1769, have grown to be among the most important and extensive in Europe.

The best and easiest route to Le Creusot is by the railway which branches from the Paris and Lyons line a little south of Beaune, to Montchanin, and from thence by another line communicating with Nevers, which passes close to the works. Le Creusot now has a population exceeding 25,000 souls, all more or less connected with the works. In 1782 Le Creusot bore the name of Charbonnières, given to it in consequence of the discovery of coal near the village and close to the surface of the ground. The discovery having been communicated to Louis XVI. a company was formed, under his patronage, to work the mine; and as laborers were scarce, the king placed a regiment of soldiers at the disposal of Gauthey, engineer-in-chief to the States of Burgundy, who was appointed to open the mine. Shortly after a steam engine, constructed by Watt, was brought over from England, the cylinder of which is carefully preserved as an interesting relic. By means of this engine considerable quantities of coal were raised, and the almost simultaneous discovery of iron ore near the coal gave a fresh stimulus to the company. By order of Louis XVI. and on his death by that of the chiefs of the revolution, a great number of cannon and cannon-balls were cast here; and the hill where the guns were proved and tried was called Les Boulets, by which name it is still known. After the revolution Le Creusot passed into the hands of the brothers Chagot, under whose direction various iron works were erected and all the gas-pipes for Paris made. In 1826 the above gentlemen disposed of the works to an English company—Manby and Wilson—for the sum of 2,620,000 frs. But the concern did not prosper in their hands—the company collapsed; and in 1837 the establishment was purchased by the Brothers Schneider, one of whom had been long engaged in commerce in Paris, while the other had been trained among the forges of the Ardennes. An unfortunate accident terminated the life of the elder of those brothers in 1845, since which period the management has been in the hands of M. Eugène Schneider (the well-known President of the French Corps Législatif), who has developed its resources to their present gigantic proportions—how gigantic may be conceived from the fact that while in 1837 the workmen did not exceed 1,000, they now number 11,000.

The greater portion of the iron ore worked at Le Creusot is obtained from Mazenay, at the junction of Burgundy and Maconnais. This ore yields 28 per cent. of iron, and extends over a vast area. The vein, which in no place is more than 130 feet from the surface of the ground, averages 6½ feet in thickness. The present annual yield is 262,000 tons. The ore is conveyed by a special railway to Le Creusot, where it is passed through enormous blast-furnaces of the most approved construction. Large as is the supply of iron ore from Mazenay, it does not meet the requirements, and other mines feed these great works. Among these is the famous Algerian Mine of magnetic iron ore at Mokta-el-Hadid, which yields no less than 65 per cent. of excellent iron, and of which large quantities are now shipped to Dunkirk, where it is sold at 1*l.* 8s. 10d. per ton.

To meet the great and continually increasing demand for steel, enormous works for carrying on the Bessemer process are being erected, which, when completed, will extend the total area of the works to 357 acres. But perhaps the most impressive department of this establishment is that of the forges, contained in a shed covering no less than 29.65 acres, and containing 68 steam-hammers, 672 machines of various kinds, and 85 steam-engines.

With respect to steam-hammers, it is due to our neighbors to state that they claim the invention of this most useful machine for their countryman M. Mourdon, who took out a patent for its construction in April, 1842, whereas Mr. Nasmyth, to whom the invention is gen-

erally attributed, did not, as they say, take out his patent in England until June in the above year, having, moreover, visited Le Creusot between the above months.

The shed containing the workshops for the construction of locomotives, marine and the other steam-engines, iron bridges, pontoons, etc., is scarcely inferior in extent to that devoted to the forges. It contains 37 steam-hammers, and 567 machines of various kinds. Locomotives are building here for nearly all the States in Europe.

That the flourishing condition of Le Creusot is partly due to the enormous supplies of iron ore and coal at its very door is unquestionable; but credit must be also given to the admirable management prevalent throughout all the departments. Its large and continually increasing business must also be ascribed, in a great measure, to the fact that the wages of the skilled workmen are below those received by English operatives of the same class. According to the information communicated, the wages paid to plate-rollers is 10 frs. for 10 hours' labor, and the first-class workmen engaged on locomotives receive only 5 frs. The average daily wages of all the workmen is now 3 frs. 45 cents. Low as these wages are, compared with those paid to English artisans in our iron works, the prices of provisions at Le Creusot are such as to enable the operatives to live comfortably within their incomes. The rent of a house, containing 3 rooms, varies from 100 to 125 frs. per annum; and the average living expenses of a family consisting of 3 persons is stated to be 1 fr. 50 cents per day. Great facilities are given to the workmen to purchase the houses which they occupy. The average cost of these is 1,800 frs.; and at present 2,131 workmen own the houses in which they live. Several excellent, and almost gratuitous schools exist in the town, the payment exacted being only 75 cents. per head monthly. Boys are taught reading, writing, grammar, arithmetic, and drawing; and those who manifest intelligence, and a decided capacity for mechanics, are sent, at the expense of the company, to the High School of Arts and Métiers at Aix, from whence they are drafted to Le Creusot when their education is completed.

From a statistical document, it appears that during the 15 years ending 1865, out of the entire population only 632 persons were sentenced to punishments for crimes, and these were of very light nature. Drunkenness—that curse of our country—is very rarely seen at Le Creusot; and woman beating, which disgraces English working communities, is, it may be said, entirely unknown.

Mineral Wealth of Missouri.—There are three copper fields in Missouri. These extend through Franklin, Crawford, Dent, Shannon, Wayne, Madison, and Iron counties, and include 500,000 acres of copper lands. The practical geology, topography, surface signs, and ores discovered and mined in these copper fields, indicate that the repletion, or filling of these copper veins, is on a scale of magnitude corresponding to the iron-producing action that formed the Iron Mountains. No copper has been mined in Missouri since 1856.

There are 2,000,000 acres of lead fields in Missouri; 30,000 acres have been mined and yield $25,000,000 worth of lead. This lead was made from ore from "clay diggings," which is the croppings of veins in the rock.

The value of pig-iron made in Missouri in 1867 was about $1,000,000, lead $300,000; no copper, zinc or nickel. Value of pig-iron made in Pennsylvania in 1867, in round numbers, $30,000,000. Missouri contains a much richer character of iron ores than Pennsylvania, and ten times the quantity.—*Iron Age.*

The Petroleum Trade.—Philadelphia ships about half of the petroleum sent abroad from the United States. Pittsburgh is the principal market for the article west of the Alleghanies. From January 1st to November 14th of the year just past, Philadelphia exported 33,665,224 gallons of petroleum. In the same period, the exports from Boston amounted to 2,267,517, and from Portland 580,400 gallons. During the same period in 1867, the exports from Philadelphia to foreign ports were 25,621,005 gallons, showing an increase this year of upwards of 8,000,000.

CARBON IN STEEL.—Hardened steel leaves no carbonaceous residue on solution in muriatic or diluted sulphuric acids; unhardened steel also leaves none when dissolved at as high a heat as possible with exclusion of air; but it leaves such a residue when solution is not at first or at the proper time aided by heat. This residue is not dissolved by further heating.

Percentage of	Comb. Carbon.	Graphite.	Total Carbon.	Nitrogen.
Cement steel unhardened drawn under hammer and hammered cold	1.20	0.30	1.50	0.016
Cement steel unhardened drawn	1.24	0.30	1.54	.....
Cement steel hardened drawn	1.48	0.02	1.50	0.016
Bessemer steel unhardened No. 2	2.02	0.20	2.22	0.005
" " 3¼	1.17	0.10	1.27	0.005
Bessemer's steel hardened " 3¼	1.23	0.00	1.23	0.005
Bessemer steel without spiegeleisen, red short	.....	.....	0.40	0.006
Bessemer steel with spiegeleisen not, red short	.....	.....	0.45	0.008

—RINMAN *in Erdman's Journal.*

WOOD suitable for cabinet making and decoration, according to a report on the woods in the Paris Exhibition, exists in much larger quantities and of much greater variety than is generally supposed. But a small number of the hard and beautifully colored and variegated woods that are accessible in various countries, have been brought into use.

Another report magnifies the value of wood to the world, deprecates the reckless waste of timber in new countries, and advocates the enactment of better laws for the preservation of forests.

THE STRENGTH OF CORRUGATED IRON.

BY J. E. HART, C. E.

From the "Bombay Builder," August, 1868. With comments by Professor Rankine, from "The Engineer," November 13, 1868.

The following are the experiments on the transverse strength of corrugated iron, alluded to in a letter published in the May number of the above journal:

The iron experimented on was supplied by Messrs. Nicol & Co., Bombay, and supposed to be of the following gauges: 8 BWG, 10 BWG, 12 BWG, 16 BWG, 22 BWG. The sheets or plates were supported on trestles, and loaded in their middle by weights suspended in a scale pan. The bending action of the load was distributed along the transverse axis by a rigid bar of timber laid across the sheet at right angles to the corrugations, and the pressure of this bar was distributed to ridge and furrow by a layer of damp sand. Fastened to this bar by a cotter was a flat strip of steel, which, passing through a slot in the sheets, suspended a stirrup with an universal joint carrying a roughly made scale beam. The dimensions of the slot were three-fourths of an inch long by one-fourth of an inch wide.

The object of this arrangement was to obviate any unequal strain on one side or other of the sheets through the oscillations of the load in the scale pan. The tressles were movable along sleepers sunk in the ground, so that the bearings of the sheets could be altered at pleasure. The deflections were measured with a scale of 50ths of an inch, which was hung from the lower side of the sheets between silk threads stretched by weights between the tressles. The thicknesses of the sheets were measured with a scale of 100th of an inch, read off with a magnifying glass. The sheets broken were of various lengths in order to test the accuracy of the formula; for the same reason the bearings were made to vary; and in order that the comparison might be closer several of the broken sheets were again subjected to experiment. The constant, or modulus of rupture arrived at, is on the whole sufficiently uniform, and establishes fairly Professor Rankine's approximate formula for the moment of resistance of corrugated iron (see "Manual of Civil Engineering," chap. v., sec. iv., art. 375).

$$\frac{4}{15} f_a^{hbt} \ldots$$

which equated with the bending moment for a central load gives—

$$\frac{4}{15} f_a h b t = \frac{W l}{4} \text{ whence}$$

$$f_a = \frac{15\ W l}{16\ h b t}$$

by which formula the modulus of rupture fa is calculated.

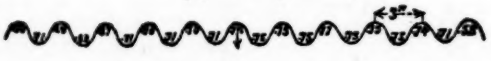
In the formula :

W = The total load in pounds;
h = The height of the corrugations measured from ridge to furrow;
b and t = The breadth and thickness respectively of the sheets in inches;
l = The bearing or span between supports in inches.

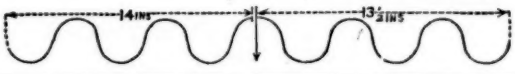
The heights of the corrugations were found to be very unequal, not only in adjacent ridges and furrows, but also in different parts of the same furrow. The heights given in the data are the average of all across the sheet in the middle, as shown in the sketches of the section. The outer corrugations, unless the plate was expressly cut, were not of the full depth; and their heights were rejected as an element of strength. The thicknesses varied in different sheets of the same gauge, and also slightly in different parts of the same sheet. They were measured from a piece cut out of the sheet, and carefully filed true; in a few cases, however, did they correspond with the tabular value of the thickness of the supposed gauge of the sheets. The placing and removal of the loading was effected through the medium of a lever and screw-jack, which arrangement obviated any chance of a jar of the material from jerks or vibrations of the load. Every care was taken to avoid inaccuracy, either of observation or of result.

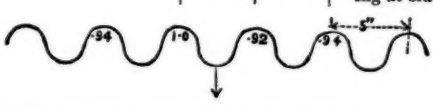
No. of experiment.	Description of Sheet.	Weight in Pounds.	Deflection in Inches.	Dimensions of Sheet and Remarks.
1	Gauge No. 22 (probably).....	164	·60	t = .029 inches.
		220	.82	l = 60 inches.
	Size of sheet, 8′ × 2′−3″.....	234	.88	b = 27 inches ∴ fa = 46567 lbs. on sq. in.
	Weight of sheet, 28 pounds.....	248	.92	h = 67 inches.
	Do. per square foot, = 1.56 pounds.....	262	1.00	
		276	1.08	Yielded slowly on adding last weight by tearing off lower corrugations on each side of slot in middle.
		290	1.14	
		304	1.22	
		430	broke.	

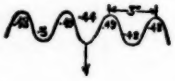
2	Gauge No. 20.....	90	.18	t = .035 inches.
		146	.28	l = 60 inches.
	Size of sheet, 6′ × 2′−7¾″.....	202	.40	b = 31.75 inches ∴ fa = 45628.
	Weight of sheet, 29 pounds.....	258	.52	h = .71 inches.
	Do. per square foot=1.83 pounds	314	.64	
		370	.78	
		426	.96	
			ultimate	
		640	6.8	
		641	broke.	

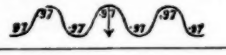


No. of experiment.	Description of Sheet.	Weight in Pounds.	Deflection in Inches.	Dimensions of Sheet and Remarks.
2a	Uninjured end of above sheet rebroken .	1448	broke	l = 30 inches. h = .72 inches . ∴ fa = 50900.
3	Gauge No. 17	.46	.08	t = .06 inches.
		102	.12	l = 60 inches.
	Size of sheet, 6′ × 2′ − 3½″	158	.20	b = 27.5 inches . ∴ fa = 41663.
	Weight of sheet, 38 pounds.....	214	.31	h = .95 inches.
	Do. per square foot = 2.76 pounds.....	382	.40	
		1161	broke	Two separate sheets with weight hung between the right-hand sheet failed first.
3a	Uninjured end of above sheet rebroken .	1018	broke.	l = 30 h = .86. b = 3.5 . ∴ fa = 41101
4	Gauge No. 17	160	.12	t = .06 inches.
		272	.22	l = 60 inches.
	Size of sheet, 6′ × 2′ − 3¾″	384	.34	b = 27.75 inches . ∴ fa = 43528.
	Weight of sheet, 38½ pounds.....	496	.46	h = .95 inches.
	Do. per square foot = 27.7 pounds	720	.72	Yielding slowly with puckering of the top corrugation, and spreading at sides.
		1224	broke	
5	Gauge No. 13 or 12.....	260	.28	t = .096 inches.
		596	.46	l = 60 inches.
	Size of sheet, 6′ × 2′ − 9″	1044	.68	b = 33 inches.
	Weight of sheet.....	1794	a	h = .9 inches.
	Do. per square foot.....	1895	c	a here received a shock from slipping of lifting tackle.
		2114	d	c do. do. do.
		2160	broke	d plate began to sink visibly, giving most at side where h was least.
6	Guage No 12.....	151	.12	t = .1
		263	.20	l = 48 inches.
	Size of sheet, 6′ − 0¼″ × 0 − 10.1″	375	.30	b = 10.1 inches . ∴ fa = 49770.
	Weight of sheet, 24.5 pounds	487	.38	h = .94 inches.
	Do. per square foot, 4.84 pounds	599	.46	
		1050		





No. of experiment.	Description of Sheet.	Weight in Pounds.	Deflection in Inches.	Dimensions of Sheet and Remarks.
6a	Uninjured end of above sheet rebroken..	1768	....	$l = 30$ inches $\therefore fa = 52376.4$.
6b	Do. do. do. ..	2210	....	$l = 24$ inches $fa = 52374.6$.
7	Guage No. 12.....	152 264	.10 .18	$t = .1$ $l = 48$ inches.
	Size of sheet, 6′−0½″×0′−99″.....	376	.26	$b = 99$. inches $\therefore fa = 46124.4$.
	Weight of sheet, 23.5 pounds.....	488	.30	$h = .95$ inches.
	Do. per square foot, 4.73 pounds.....	600 768 964	.44 .60 broke	
8	Gauge No. 13 or 12.....	90 146	.44 .72	$t = .095$ inches. $l = 60$ inches.
	Size of sheet, 6′×1′.....	202	1.0	$b = 12$ inches $\therefore fa = 43099$.
	Weight of sheet, 27 pounds.....	258	1.36	$h = .49$ inches.
	Do. per square foot, 4.50 pounds.....	314 428	1.8 broke	
				
9	Gauge No. 13 or 12.....	90 146	.34 .58	$t = .095$ inches. $l = 60$ inches.
	Size of sheet, 6′×1′.....	202	.80	$b = 12$ inches $\therefore fa = 41959.4$.
	Weight of sheet, 28 pounds.....	258	1.04	$h = 56$ inches.
	Do. per square foot, 4.66 pounds.....	314 426 ...	1.26 2.10 ultimate	These two sheets 8 and 9 are rolled to sharper curves at the corrugations than others, and approach the zigzag form. They are also got from the same whole sheet cut in half, and show a curious discrepancy in the height of corrugations.
		480 483	2.78 broke	
10	Gauge No. 12 or 11.....	212 436	.12 .20	$t = .12$ inches. $l = 60$ inches.
	Size of sheet, 6′×2′−9″.....	660	.26	$b = 33$ inches $\therefore fa = 58940$.
	Weight of sheet, 103 pounds.....	884	.32	$h = .964$ inches.
	Do. per square foot, 6.24 pounds.....	1108 1332 1780 4000	.36 .44 .56 broke	

No. of experiment.	Description of Sheet.	Weight in Pounds.	Deflection in Inches.	Description of Sheet and Remarks.
11	Gauge No. 12 or 11	90	.06	$t = .115$ inches.
		202	.10	$l = 60$ inches.
	Size of sheet, $6' \times 2'-9''$	426	.20	$b = 33$ inches $\therefore fa = 46373$.
	Weight of sheet, 88 pounds.....	650	.30	$h = .964$ inches.
	Do. per square foot, 5.34 pounds.....	762	.34	
		900	.40	
		1251	.58*a*	*a*, Load removed, plate returned to the horizontal.
		2750	.18	
		3072	broke *b*	*b*, Ultimate deflection observed at 3000 was 4′ 6″.
12	Gauge No. 9.....	202	.18	$t = .15$ inches.
		426	.36	$l = 60$ inches.
	Size of sheet $6' \times 1'-3''$.....	650	.50	$b = 15$ inches $\therefore fa = 47760$.
	Weight of sheet, 49 pounds.....	874	.60	$h = .97$ inches.
	Do. per square foot, 6.53 pounds	1110	.84	
		1334	1.02	
		1558	1.40	
		1850	broke	
13	Gauge No. 2.....	202	.20	$t = .15$ inches.
		426*a*	.36	$l = 60$ inches.
	Size of sheet, $6' \times 1'-3''$.....	650	.52	$b = 15$ inches $\therefore fa = 43281$.
	Weight of sheet, $47\frac{3}{4}$ pounds.....	874	.64	$h = .96$ inches.
	Do. per square foot, 6.36 pounds.....	1098	.80	
		1322*b*	1.02	*a*, Outer edge began to cripple.
			ult. def.	*b*, Load removed and sheet returned
		1660	2.84	to deflection of .94 only.
		1662	broke.	

Mean value of $fa = 46682$ from all experiments, or $= 46916$, omitting No. 10.

It appears from these experiments that the highest and lowest values of $f\ a$ are respectively 58,940 and 41,101; the former of these extreme values I would reject as open to suspicion, because of the great discrepancy between the breaking load of it, and its sister sheet (No. 11). The mean value of $f\ a$ from the remaining experiments would be, as nearly as might be, 46,000, and this may, I think, be adopted as its true value. Experiments 2, 2*a*, and 6, 6*a*, show that the strength varies inversely as the length, although a slight of increase of strength appears in the shorter sheets, which may be accounted for by the deflection being less. The breadth does not appear to influence the constant, so that we may assume the strength to vary as this dimension. The depth also of corrugation does not appear to influence the result other than directly; that is, however, a point that could only be examined by having similar sheets rolled of varying depths of corrugations. However, Experiments 5, 8, and 9, afford a comparison as far as it goes. Experiments 6, 7, 12, and 13, show that in narrow sheets the position of the side edge, whether in tension or compression, makes a difference. This would appear to be a necessary consequence of the laws of strength of materials, and it was observable that when the side edges of the plates were up, as in Experiment 7, the edges cripped early in the experiment; while when they were down, as in Experiment

6, they did not fail till later. All plates first showed symptoms of failure at the side edges. None of the plates gave way suddenly, but each sank slowly when the breaking weight had been reached. As a rule, they appeared to fail by the spreading of the corrugations at the middle, and did not crush at the tops of the ridges; on the contrary, when the sheet was allowed to sink till rupture of the material took place, fracture occurred by tearing of the furrow commencing from each side of the central slot, and proceeding towards the sides of the sheet at right angles to its length.

It is probable that had the sheet been prevented from spreading by strips riveted across it, as recommended by Professor Rankine, the constant would have increased in value. In bridges the adjoining sheets would act so as to oppose the spreading, and this may be looked upon as an element of strength. The results of the observations of the deflections seem to be uniform, but at present no deductions from them are made. The ultimate deflections were in a few instances observed as a matter of curiosity, but in most cases it was not possible to hit off the very extreme deflections. I find that the increased value of the constant or modulus of rupture derived from the preceding series of experiments will so considerably modify the conclusions of my former communication that it is desirable that I should revise some of my previous calculations, and I therefore venture to go over some of the ground again, connecting and enlargening some of the deductions I have already made.

REMARKS BY PROF. W. J. MACQUORN RANKINE.

1. Reference to Mr. Hart's Researches.—A valuable series of experiments by Mr. Hart, on the transverse strength and stiffness of corrugated iron, have been published in the "Bombay Builder" for August, 1868, and reprinted in "The Engineer" of the 10th October, 1866, page 298. Mr. Hart shows that the results of those experiments agree very fairly with a formula proposed by me a few years ago* for the breaking moment of a sheet of corrugated iron, viz:

$$\frac{Wl}{4} = \frac{4}{15} f h b t; \quad \ldots \quad (1)$$

in which l denotes the span; W, the breaking load hung at the middle of the span; b, the breadth of the sheet, and t, its thickness; h the depth of the corrugations from ridge to furrow; and f the coefficient or modulus of rupture. Values of that coefficient are calculated by Mr. Hart from his experiments by means of the following formula:

$$f = \frac{15}{16} \frac{Wl}{hbt}; \quad \ldots \quad (2)$$

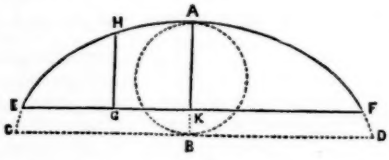
and they are found to range from 41,100 pounds to 58,940 pound on the square inch; the mean value being about 46,000 pounds on the square inch. There can be no doubt then that the formula of Equation 1 may be safely used in practice to calculate the probable breaking load of sheets of corrugated iron of given dimensions; and that, in the absence of special experiments on the strength of the particular material that is used, the smallest of the values deduced from Mr. Hart's experiments, viz., 41,100 pounds on the square inch, may be taken as the modulus of rupture in the calculation.

2. Objects of this Communication.—The objects of the present communication are to explain the theoretical reasoning on which the formula of Equation 1 is founded, and the extent to which it is approximative; to determine, by the aid of Mr. Hart's experiments on breaking loads, values of the modulus of rupture according to a rule which gives a closer approximation; and to deduce, from his experiments on deflection, values of the modulus of elasticity of corrugated iron.

3. Assumption of a Cycloidal Cross Section.—The first step towards finding formulæ for the transverse stiffness and strength of a given piece of material, is to determine the geometrical moment of inertia of the transverse section relatively to a horizontal axis passing through its centre. In a sheet of corrugated iron, the transverse section is a narrow band of uniform width equal to the thickness of the sheet, and of a wavy figure, composed of a series of curved arcs, alternately above and below the horizontal axis of the section. These curved arcs usually approximate nearly in shape to arcs of circles; and no material error in practice is occasioned by assuming for

* "Manual of Civil Engineering," page 543.

their figure any curve which does not greatly differ from a circular arc. A cycloidal arc is such a curve; and it has geometrical properties which cause the calculation of its moment of inertia to be a very simple process; therefore the figure of cross section of each of the ridges and furrows of the sheet of iron will be assumed to be a cycloidal arc, such as E A F in the figure; where C A D represents a complete cycloid, traced by a point in the circle A B, which rolls on the



straight base line C D; and the chord E F, parallel to C D, is drawn in such a position as to cut off an arc E A F, in which the depth A K bears to the breadth E F the same proportion as in the corrugations of the iron. That is to say, let a be the width of one corrugation, measured *from ridge to ridge*, and h (as before) the depth *from ridge to furrow;* then the chord and the depth of the cycloidal arc are respectively,

$$\text{E F} = \frac{a}{2}, \text{ and A K} = \frac{h}{2}.$$

4. Geometrical Moment of Inertia.—One of the geometrical properties of the cycloid is as follows: The perpendicular distance H G, of any point H in the arc, from a chord E F parallel to the base line, varies proportionally to the product H E $\times$ H F of the two parts into which the arc E A F subtended by the chord is divided by the point H. To express this in algebraical symbols, let the arc A E = A F = c; the arc A H = s, the greatest ordinate A K = $\frac{h}{2}$ (as before); and the ordinate H G = y; then we have

$$y = \frac{h}{2} \cdot \frac{(c+s)(c-s)}{c^2} = \frac{h}{2}\left\{1 - \frac{s^2}{c^2}\right\}.$$

Let $d\,s$ denote an indefinitely short or elementary arc, situated close to the point h. Then the geometrical moment of inertia of $d\,s$ relatively to the axis E F is $y^2\,d\,s$; and that of the arc A E is expressed by the following integral:

$$\int_0^c y^2\,d\,s = \frac{h^2}{4}\int_0^c d\,s.\ \left\{1 - \frac{s^2}{c^2}\right\}^2 = \frac{2\,h^2\,c}{15};$$

which, being divided by the length c of that arc, gives, for the *square of its radius of gyration*,

$$\frac{2\,h^2}{15}.$$

To find the geometrical moment of inertia of the cross section of a sheet of corrugated iron, the area of that section is to be multiplied by the preceding expression for the square of the radius of gyration: that is to say, let A be that area, and I the moment of inertia; then

$$\text{I} = \frac{2\,h^2\,\text{A}}{15} \quad \ldots\ldots \quad (3)$$

5. Formulæ for Strength and Stiffness.—The following are the well-known general formulæ for the modulus of rupture f, and modulus of elasticity or stiffness E, of a beam of uniform cross section loaded in the middle:

$$f = \frac{h}{2\text{I}} \cdot \frac{\text{W}\,l}{4}; \quad \text{E} = \frac{\text{W}'\,l^3}{48\,\text{I}\,v};$$

in which W is the breaking load; W′ any load not exceeding the limits within which the deflection increases in the simple ratio of the load; and v the deflection with the load W′. When the value of I given by Equation 3 is substituted in these formulæ, they become respectively as follows:

$$f = \frac{15\,\text{W}\,l}{16\,h\,\text{A}}; \quad \ldots\ldots \quad (4)$$

$$\text{E} = \frac{5\,\text{W}'\,l^3}{32\,h^2\,\text{A}\,v}. \quad \ldots\ldots \quad (5)$$

6. Determination of Sectional Area—Use of a Virtual Thickness.—A rough approximation to the sectional area of a sheet of corrugated iron may be obtained by simply multiplying together the breadth and thickness; that is, making

$$\text{A} = b\,t \quad \ldots\ldots \quad (6)$$

This is the approximation used in Equations 1 and 2. It always gives too small a value of the area; and hence, in using it to calculate the probable breaking load of a sheet of corrugated iron with a coefficient taken from experiments on iron in other forms, the errors to which it leads are always on the safe side; and this was the reason which induced me to adopt it in the book already re-

ferred to. It is obvious, on the other hand, that in calculating the modulus of rupture from experiment by means of the same approximation, the value obtained is greater than the actual stress on the material just in the same proportion in which the exact sectional area is greater than the approximate sectional area.

The length of the cycloidal arc E A=c in the figure is given with an error in defect which in no case exceeds $\frac{1}{1000}$ part, by the approximate formula:

$$c = \frac{a}{4}\left(1 + \frac{8h^2}{3a^2}\right) \text{ nearly};$$

from which it appears, that a second approximation to the sectional area of the sheet is given by the following formula:

$$= \left(1 + \frac{8h^2}{3a^2}\right) bt \quad . \quad . \quad . \quad . \quad (7)$$

Considering, however, how much more precisely the operation of weighing can be performed on a thin sheet of metal than that of measuring its thickness, it is obvious that by far the most accurate way of determining the sectional area of the sheet is to calculate it from the weight of a given horizontal area; and such, accordingly, is the method employed in a new reduction of the results of Mr. Hart's experiments. Mr. Hart gives, in each case, the weight in pounds per square foot of the sheet of corrugated iron experimented upon. That weight, in the following calculations, is divided by 40 (being the weight in pounds of a plate of iron a foot square and an inch thick), to give what may be called the *virtual thickness* of the corrugated iron; that is, the thickness of a *flat* sheet of iron of the heaviness of 480 pounds to the cubic foot, and of the same horizontal area and weight with the corrugated sheet. The product of the breadth and virtual thickness gives the sectional area: that is,

$$A = bt' \quad . \quad . \quad . \quad . \quad . \quad (8)$$

in which t' denotes the virtual thickness.

It may be remarked that the value of A, as given by Equation 8, is found in most, though not in all, of Mr. Hart's experiments to be somewhat greater than that given by Equation 7. It is probable that this may be caused by the iron being compressed in the process of rolling to a greater density than 480 pounds to the cubic foot. It is clear, nevertheless, that Equation 8 is the preferable formula; for in calculating the modulus of rupture and the modulus of stiffness, it eliminates the effect of such compression of the iron.

7. Method of Calculating the Modulus of Rupture.—In calculating corrected values of the modulus of rupture, the method followed has been to multiply each of the values given by Mr. Hart by the ratio $\left(\frac{t}{t'}\right)$ in which the measured thickness used in his calculations, is less than the virtual thickness used in mine. The results are given in the annexed table (A). They are computed to three places of figures only, as it would be useless to attempt greater precision. The difference between the extreme values is less, as compared with the mean value, than in the case of the values deduced by Equation 2 from the measured thicknesses, as the following statement shows:

Values in pounds on the square inch deduced from

Measured thicknesses.		Virtual thicknesses.	
Greatest (No. 10)	58,940	(No. 10)	45,300
Least (No. 3a)	41,101	(No. 9)	34,200
Difference	17,839		11,100
Mean	46,682		39,100

8. Method of Calculating the Modulus of Stiffness.—The values of the modulus of stiffness are calculated by means of Equations 5 and 8, from data selected from those parts of Mr. Hart's record of experiments in which the deflection increased in the simple ratio of the load, or nearly so. The results are given in the annexed table (B). They are computed to four places of figures only. The difference between the greatest and least values is, as compared with the mean value, a little less than the corresponding difference for the modulus of rupture, as the following statement shows:

	Pounds on the square inch.
Greatest value (No. 2)	23,290,000
Least value (No. 11)	17,760,000
Difference	5,530,000
Mean value	20,420,000

Table (A) of Values of the Modulus of Rupture of Corrugated Iron, as Deduced from Mr. Hart's Experiments, with Virtual Thicknesses, Calculated from the Weights per Square Foot.

No. of experiment.	Modulus as calculated from measured thickness.	Measured thickness.	Virtual thickness.	Corrected modulus as calculated from virtual thickness.
	Pounds on the square inch.	inch.	inch.	Pounds on the square inch.
1	46,567	.029	.039	34,600
2	45,628	.035	.046	34,700
2a	50,900	.035	.046	38,700
3	41,663	.060	.069	36,250
3a	41,101	.060	.069	35,800
4	43,528	.060	.069	37,900
6	49,770	.100	.121	41,100
6a	52,376	.100	.121	43,300
6b	52,375	.100	.121	43,300
7	46,124	.100	.118	39,100
8	43,099	.095	.113	36,400
9	41,959	.095	.116	34,200
10	58,940	.100	.130	45,300
11	46,373	.115	.133	40,000
12	47,760	.150	.163	43,900
13	43,281	.150	.159	40,800

Mean from 16 experiments in pounds on the square inch 39,100
Mean in kilogrammes as the square metre 27,500,000
Mean in lineal feet of iron, weighing 480 pounds to the cubic foot 11,730
Mean in lineal metres of iron, weighing 7,690 kilogrammes to the cubic metre 3,575

Table (B) of the Values of Modulus of Stiffness of Corrugated Iron as Deduced from Mr. Hart's Experiments, with Virtual Thicknesses Calculated from the Weights per Square Foot.

Number of experiment.	Load pound.	Deflection inch.	Modulus of stiffness in pounds on the square inch.
1	262	1.00	18,710,000
2	314	0.64	23,290.000
4	384	0.34	20,830,000
6	599	0.46	20,830,000
7	600	0.46	22,280,000
8	258	1.36	19,760,000
9	314	1.26	19,170,000
10	1,332	0.44	21,350,000
11	1,251	0.58	17,760,000
12	1,334	1.02	19,540,000
13	1,098	0.80	21,080,000

Mean from 11 experiments in pounds on the square inch 20,420,000
Mean in kilogrammes on the square metre 14,360,000,000
Mean in lineal feet of iron weighing 480 pounds to the cubic foot..... 6,126,000
Mean in lineal metres of iron, weighing 7,690 kilogrammes to the cubic metre 1,867,000

9. RULES.—The following are the rules for practical purposes to which the results deduced from Mr. Hart's experiments in this communication lead:

I. Let b be the breadth of a sheet of corrugated iron, h the depth of the corrugations from ridge to furrow, and w the weight of an unit of the area of the sheet, as projected on a plane: to find the least probable *breaking moment*, M.

Calculate a virtual thickness, t', by the formula $t'=w \div k$; where k has the following values:

For w in pounds to the square foot, and t' in fractions of an inch; $k=40$.

For w in kilogrammes to the square metre, and t' in fractions of a metre; $k=7{,}690$.

Then

$$M=\frac{4}{15} f h b t'. \quad . \quad . \quad . \quad . \quad (9)$$

Least value of f;
For forces in pounds, dimensions in inches, and moments in inch-pounds. . 34,200
For forces in kilogrammes and dimensions in metres. . 24,000,000

II. Given, the intended least breaking moment M, the breadth b, and the depth of corrugation h, of a sheet of corrugated iron; to find the proper weight w of an unit of area;

$$w=k t'=\frac{15 k M}{4 f h b}. \quad . \quad . \quad . \quad (10)$$

Values of the factor

$$\frac{15 k}{4 f};$$

For w in pounds to the square foot, load in pounds, and dimensions in inches;

$$\frac{1}{228}=.00358;$$

For forces in kilogrammes and dimensions in metres;

$$\frac{1}{832}=.0012.$$

III. To find the *probable deflection* (v_1), *under half the breaking load*, of a given sheet of corrugated iron; l being the span.

$$v_1 = \frac{n''}{m'} \cdot \frac{f}{2E} \cdot \frac{l^2}{4h}; \quad . \quad . \quad . \quad (11)$$

In which

$$\frac{f}{2E} = .00096 = \frac{1}{1040}; \text{ and } \frac{n''}{m'}$$

has the following values:

Sheet loaded in middle of span $\frac{2}{3}$;

Sheet uniformly loaded, $\frac{5}{6}$.

The following later contribution to the "Bombay Builder" apparently concludes Mr. Hart's valuable paper on this subject:

Buckled plates—the invention and patent of R. Mallet, Esq., M. I. C. E.—are also an admirable substitute for wooden planking in the platforms of bridges, and have been extensively used in both England and India, the most notable instances being the Westminster and Soan bridges. They are square or rectangular plates domed in the centre, with a flat margin or "fillet" all round.

The versed sine or central rise is small, being about one twenty-fourth the greatest length of side. The fillet is from 2 inches to 6 inches wide, according to size of plate, etc. The material may be either iron or steel, and is protected from corrosion by a coating of some preservative composition, that recommended by the inventor being well-boiled coal-tar mixed with powdered caustic lime. In this the iron heated to black red (700° Fah.) is to be quenched. Steel plates will be half the weight of iron ones. Buckled plates possess certain advantages over corrugated sheets; for instance, they produce greater lateral stiffness in the platforms, and are said to be less perishable, owing to the fibre of the iron being less injured by the process of manufacture. They are lighter, and, of course, ought to be cheaper, because less material is used in an equal horizontal area of plate, the loss of plane surface in buckled plates being about one-seventieth of the original plate, while in corrugated sheets the loss is between one-fifth and one-fourth. On the other hand, to obtain full advantage of the strength of buckled plates, they must be supported all round. This leads to considerable expense in the arrangement of the girders and joists, and, except in iron structures, the requisite conditions cannot be readily obtained. Mr. Mallet states that the resistance of square buckled plates is directly as the thickness, and inversely as the clear bearing. That the resistance of a rectangular plate is nearly the same as that of a square plate whose side is equal the longer dimension of the oblong one, and that the longer edge should not be more than double the shorter. Also, that a plate fastened firmly on all its sides has double the strength of a plate merely supported all round; and if two opposite sides are wholly unsupported, its resistance is reduced as 8 to 5. In Rankine's "Civil Engineering," Section IV., Article 375, Division III., is the following formula for the resistance of a buckled plate.*

$$M = \tfrac{4}{15} f_s l h t \quad . \quad . \quad . \quad . \quad . \quad (20)$$

which is nearly the same as that given for corrugated iron. In this formula $f_s = 21{,}600$, l is the length of that section of plate at which the greatest bending moment is exerted; t, the thickness of the iron; h, the depth of curvature at the centre. If we suppose the plate to be supported at the ends only, the bending moment of the distributed loads is $= \frac{W l}{8}$, hence the equation for the dimensions of the plate is

$$\frac{W l}{8} = 5760\, l h t$$

$$\therefore W = 46080\, h t \quad . \quad . \quad . \quad . \quad (21)$$

and if, as before, we take $w s = 200$, and since, as explained at equation 14, $W = W s L B$, therefore

$$t = \frac{200\, L B}{46080\, h} = \frac{L B}{230.4\, h} \quad . \quad . \quad . \quad (22)$$

If the factor of safety be 4, we have

$$t = \frac{L B}{57.6 h} \quad . \quad . \quad . \quad . \quad (23)$$

and if

$$h = \frac{l}{24} = \frac{L}{2};$$

then

$$t = \frac{B}{28.8} = .03473\, B \quad . \quad . \quad . \quad (24)$$

* It is, I think, doubtful whether this formula will apply equally well for plates supported and fixed; but I have assumed that such is the case, basing my assumption on the treatment of the analogous case of beams fixed at both ends by the author himself.

For the square plates B = L, and the corresponding thicknesses of plates are as follows :—

L =	2,	2½,	3,	3½,	3,	4½,	5,	5½,	6;
t =	.069,	.087,	.104,	.122,	.139,	.156,	.174,	.191,	.208;
Nearest corresponding gauge..... =	16,	14,	12,	11,	9,	8,	7,	6,	5.

The cost of buckled plates, compared with corrugated sheets, may be obtained thus :

Let the gauge be assumed to be 12 deg. to 14 deg.; therefore, the weights per 100 square feet will be for 14 gauge =

$$\left(3.12 + \frac{3.12}{70}\right) 100 = 316.8 \text{ pounds} = .14 \text{ tons};$$

12 gauge=

$$\left(4.38 + \frac{4.38}{70}\right) 100 = 444.3 \text{ pounds} = .2 \text{ tons}.$$

The cost per ton is £13 in England, plus £7 for freight and carriage to 100 miles from the coast, equal, say, Rs. 200; therefore, the cost of buckled plates would be from Rs. 28 to Rs. 40 per 100 square feet, or about one-fourth less than that of corrugated iron.

The relative cost of the three sorts of covering for platforms of road bridges may be summarized as follows:—Timber planks, Rs. 50 to Rs. 80 per 100 square feet; corrugated iron sheets, Rs. 40 to Rs. 50 per 100 square feet; iron buckled plates, Rs. 30 to Rs. 40 per 100 square feet, to each of which rates must be added the expense of fixing the material, such as spikes and carpenters' labor for the planking; rivets, bolts, and screws, with smiths' labor, for the iron.

The following table and information is extracted from a circular, by Mr. Mallet, "On Buckled Plates"

Table of Strength, Weight, and Cost.

Thickness of Plates.		Weight per square yard of buckled plates.	Weight of an equal surface of corrugated sheet of corresponding thickness.	Safe passive load uniformly diffused, per square yard, for 3-feet square plates.	Safe impulsive load uniformly diffused per square yard, for 3-feet square plates.	Cost per superficial yard of buckled plate at £13 per ton, in England.	Nearest number of square yards in one ton.	Notes, etc.
in.	B. W. G.	lbs.	lbs.	tons.	tons.	s. d.		
.048	18	17.3	20.7	0.27	0.20	2 2	129	Applicable to roofing and flooring.
.066	16	23.6	28.3	0.43	0.32	2 10	95	
.107	12	28.7	46.4	0.64	0.48	4 7	57	
⅛	Nearly 11	45.0	54.0	1.0	0.75	5 3	49	For lighter class of bridge and other floors.
3/16	Nearly 7	67.5	81.0	2.5	1.7	7 11	33	
¼	Nearly 4	90.0	108.8	4.5	3.0	10 6	24	For heavier floors of railway and other bridges and viaducts.
5/16	Nearly 1	112.5	135.0	6.2	4.7	13 2	20	
⅜	.....	135.0	162.0	9.0	6.8	15 8	16	Not as yet been found necessary in any structure.

"The size of buckled plates formed of one single rolled plate is only limited by the breadth to which sheet or plate iron can be rolled at market prices.

"The sizes that have been found most advantageous for the majority of purposes are plates of 3 feet and 4 feet square, or of those widths by the full length of the plate.

"Buckled plates may be united to each other, or to the frame of the structure they cover, by either lap or butt joints, and either by screw bolts, rivets, or wood screws to timber, and the joints made absolutely water-tight, when required, by riveting and chinking up, or by interposed strips of tape or of felt saturated in oil cement, or in tar or pitch ; or by strips of vulcanized india-rubber; or a thin layer of oil-putty.

"Economy is always consulted by supporting each plate all round. One pair of opposite fillets, resting on the girders or joists, and the other pair supported by an angle iron above, thus forming a lap plate.

"Three-feet square buckled plates are made of all the thicknesses of the above table, and 4 feet square plates of all the thicknesses except the first two, as also

any intermediate thicknesses at ordinary rates; others at extra rates. All buckled plates are charged by weight. The maker's price includes royalty.

"Prices are regulated by the 'declared rates' of the Staffordshire iron market."

THE MANUFACTURE OF PIG IRON.

BLAST FURNACE IMPROVEMENT—TREATMENT OF ORES.

UTILIZATION OF WASTE GASES.—Mr. Chas. Cochrane's paper on this subject, before the Mechanical Engineers' Association, states that with the increased capacity of the present large blast furnaces in the Cleveland district, the waste gas is so far impoverished, both in quantity and quality, that, in order to maintain a uniform supply of gas for the steam boilers and hot-blast stoves, it is of importance to utilize the whole of the gas given off from the furnace, by preventing the loss of gas hitherto occurring at the times of lowering the closing cone or bell for charging the materials at the top of the furnace. This loss amounts to fully 6 per cent. of the total quantity of gas evolved from the furnace; and the escape of the gas at the furnace mouth occasions an interruption in the supply for heating purposes, and a liability to explosion on restoring the supply at the boilers and stoves.

These objections have been obviated by the writer by a plan of doubly closing the furnace top, the ordinary closing bell and hopper being completely closed in by the addition of outer cover, containing flap doors, through which the charging materials are filled into the hopper. These doors are closed at the time of lowering the bell for dropping the charge into the furnace, so that the only escape of gas that can take place is a quantity equal to the capacity of the hopper at each time of lowering the bell, which is insignificant in amount. The plan has been in successful operation for 9 months at the Ormesby Iron Works, Middlesborough. The saving of fuel in the ovens and boilers by having a continuous flow of gas, Mr. Cochrane estimated as about 9 tons a week per furnace, which, in the year round, represented a total saving of £150 to £160. The cost of the apparatus was £200.

INCREASED SIZE OF FURNACES.—The second portion of Mr. Cochrane's paper had reference to the increased capacity of a furnace lately erected by him at the same works. The original furnace was 35 feet high and 16 feet diameter in the boshes, of a total capacity of about 7,000 cubic feet; it worked to a yield of rather over 30 cwt. of coke per ton of iron produced. The newly-erected furnace is 76 feet high and 23 feet diameter in the boshes, and of a total capacity of 20,624 cubic feet. It works to a yield of about 26 cwt. of coke per ton of iron produced, thus showing a saving of between 4 cwt. and 5 cwt. of coke per ton of iron. The Cleveland ironstone produces about 40 per cent. of iron. The author gave some interesting and detailed calculations, showing that the theoretical saving to be obtained by increasing the capacity of a furnace and thus making the materials in the upper portion act as a regenerator to take up the caloric from the incandescent materials below, was fully borne out in practical working. Following the line of these calculations, he estimated that a furnace, with 60,000 cubic feet of capacity and 113 feet high, should reduce the consumption of fuel to something like 7½ cwt. per ton of iron produced. The extreme theoretical limit of economy, when the escaping gas would be reduced to the temperature of the external atmosphere, would be reached by increasing the capacity of the furnace to about three times that of the present large furnaces in the Cleveland districts.

In the discussion of the paper it appeared that one of the Ferry Hill Furnaces, Durham, was working with 16 cwt. of coke per ton. This was partly due to the height, 105 feet (25 to 26 feet boshes), and partly to the excellent hot blast stove used; the ore yield 57 per cent. against 40 per cent. in the Cleveland district. As to high furnaces, Professor Tunner states in a report on the Paris Exposition, that the results can only be considered important locally; such hard coke and such coarse aggregates of ironstones as are worked in the Cleveland district are not to be found again soon, nor everywhere. Whether or not the American anthracite coal will sustain such a burden, has not been determined; many authorities think it will. It is of the utmost importance to the Bessemer

manufacture, at least, that the experiment be tried.

THE HOT BLAST.—An acknowledged progress has been made, says Professor Tunner, and is still becoming extended in application, in the heating of the blast to the highest possible degree. Even the coke-consuming furnaces, which are supplied with a cast-iron blast-heating apparatus, blow with air heated to 300° or 360° C.; but the blast-heating apparatus constructed upon the principle of Siemens' regenerator, of which there is also one in use at Friedrich Wilhelmshütte, near Siegburg in Westphalia, affords a still higher temperature, and would be more generally employed if its maintenance had not been found, so far, subject to so many interruptions and repairs, arising mainly from the interior lodgments of dust upon the brick heaters. With the high temperature of the blast is not only connected an enlargement of the furnace at the bottom, but at the same time a narrowing of the furnace mouth, and also with the complete disappearance of the boshes, whence has been attained the further advantage of a regular descent of the charge in work. The English and Scotch furnaces are distinguished in that way before all others.

GORMANS' GAS FURNACE.—Experiments in progress at the Gartsherrie Works are thus described: The furnace has two side channels or pockets extending vertically from the level of the tuyeres up to the charging platform, and forming special shafts or compartments for charging the coal into, while the ore, either all by itself, or mixed with an additional charge of coal, is brought into the blast furnace in the usual way; the furnace proper being open at the top. It is the intention to keep the coal separate from the ironstone until the former has been converted into coke, and the latter has arrived close above the tuyeres. At that place the side pockets which contain the charge of fuel open into the main stack of the furnace, and there the mixture between coke and ore takes place. The coal chambers are closed at the top, and the gas from the coal can be utilized as fuel or led into the main stack of the furnace for affecting the reduction of ore. In this manner it is expected that the ironstone will be reduced by the action of the ascending current of gas alone, and arrive at the openings of the side pockets in the state of spongy iron, or reduced metallic iron, which requires nothing but carburization for melting and running down into the hearth. The short space over the tuyeres should then act as a cupola for melting the spongy iron by means of the coke brought down into that space from the side pockets of the furnace.

"Engineering" says of this scheme:—The problem of separating the solid coal from the charge, and of reducing the ironstone by the action of gases alone, has never been brought to a satisfactory solution, however often and carefully experimented with. In the blast furnace itself the ore is in direct contact with solid carbon. In the higher zones of the furnace, where reduction takes place, an atmosphere of carbonic acid and of oxide of carbon exists at a temperature scarcely exceeding red heat, but the presence of coal and of oxygen from the iron ore seem to keep that atmosphere in a state of continuous charge between the higher and lower oxide of carbon. All particles of carbonic acid when in contact with coal become reduced to carbonic oxide, and the carbonic oxide in contact with the ore become carbonic acid again. This state of mobility or virtual motion of atoms seems to be requisite for the work of reduction, and it appears that an atmosphere of carbonic oxide alone is not capable of effecting the reduction of ironstone at that low temperature. It is clear, indeed, that the temperature maintained in the zone lowreduction is due to the presence of the solid carbon, since the process of converting carbonic acid into carbonic oxide by bringing it into combination with another atom of carbon is a cooling process absorbing fully one-third of the total heat which that carbon would evolve when completely burned in the open air. If we attempt, therefore, to effect the reduction of iron ores by a stream of carbonic oxide gas alone, we lose this cooling agency, we effect the combustion of the carbonic oxide gas at the expenses of the oxygen from the ore, and we thereby raise the temperature of the zone. The ore under these circumstances will become heated more and more until it will commence to melt without reduction. The furnace if kept hot enough at the tuyeres will then produce nothing but

liquid oxides, silicates, etc., in the form of slag, which is simply the ore melted but not reduced. To obtain such a result, however, a great supply of heat from an exterior source is necessary, since there are zones below that zone of reduction just referred to, which require heat in order to keep the molten ironstone liquid at the time when it no longer gives off oxygen to the gas in contact with it.

In a common blast furnace where no such special source of heat is available, the probable result of a separation of the coal from the ore, would be to set the whole furnace fast in a few minutes. If, on the other hand, a regenerative gas furnace, or an air-furnace fired externally, is employed for that purpose, and connected with a stack or hopper for reducing the ore by ascending gas, a continuous and very profuse supply of liquid slag can be relied on, as the result of this mode of reducing iron ores by an atmosphere or current of carbonic oxide gas.

Carbonizing Ores.—A considerable economy in the reduction of iron ores is obtained at the Almond Ironworks, in England, by previously carbonizing or coking the ores, instead of merely calcining them. The process—Aitkens'—is largely illustrated in the "Practical Mechanics' Journal" of October last. It is stated that the carbon in the ores is retained, to serve for fuel in their reduction. Almost any apparatus suitable for coking coal may be employed.

Purification of Ores.—On this subject "Engineering" says: The rationale of the process of washing iron ores after calcination is the following:—An iron ore contaminated with pyrites, when submitted to calcination, under the free access and influence of the air, takes up a certain quantity of oxygen, and by that process the pyrites and other similar combinations of sulphur and iron become converted into sulphates of iron, which are soluble in water. If then the ore is washed with a large quantity of water and for a considerable length of time, all those soluble salts, and with them the component sulphur, will be removed. The purification from sulphur is most effectively attained by washing at the Kladno Ironworks, in Bohemia, where forge iron for puddling is the staple article, and at the Ironworks of Maria Zell, in Styria, producing foundry and Bessemer pig iron.

A new method of purifying iron ores now under experiment was patented by Mr. Thomas Rowan, of Glasgow, and consists in calcination and subsequent washing, only the calcination in this instance is not a mere oxidizing process as now practised, but the ore is mixed with chorides, such as common salt or chloride of manganese, and calcined in contact with these substances, the effect being to convert many of the substances contained in the ore into chlorides. The idea of removing phosphorus from iron by the action of chlorine was originated by Dr. Crace Calvert, of Manchester, more than twenty years ago, but it appears that Dr. Calvert expected a gaseous combination of phosphorus and chlorine to be formed and passed off as a vapour either from the blast furnace or calcining kiln. Mr. Rowan's researches seem to show that none of the volatile combinations of chlorine and phosphorus are formed during such a calcination, but that a combination is formed which is soluble in water, and can be extracted from the ore by washing after the calcination is completed. The effect of washing the ore after this chloridizing calcination is the removal of the sulphate of soda and of the clorides of phosphorus formed in that process.

It has been proposed, at one of the great ironworks in the Cleveland district, to effect this calcination by charging the ironstone mixed with salt into the calcining kilns now in use, but this is not a suitable mode of working on a large scale. The time for calcination, and particularly that for washing, should be ample, and much greater than can be allowed in the calcining kiln. The calcination should be carried on close to the mines in very large heaps covered at the top and connected at the bottom with flues which lead into a chimney. The salt mixed with the ore, or, still better, dissolved in water and sent into the calcining heap in the form of small jets or streams of brine, would act upon the mass for any desirable length of time. The whole calcining heap should, after being burnt out, be immersed with water, or be percolated by a large stream or body of water for several weeks. After this the ore may be sent to the smelting

works, and the calcining kilns there will play the part of evaporators only. They will dry the ore and heat it to some extent previous to its being charged into the blast furnace.

SETTING OUT RAILWAY CURVES.

AN EASY CURVE FOR CONNECTING RAILWAY TANGENTS, WITH TABLES ADAPTED TO SETTING-OUT BY THEODOLITE.

By W. Airy, from "The Engineer."

It will, no doubt, be admitted by all who have had experience in the permanent setting-out of railways, that there is no method so rapid or accurate of setting-out curves as by theodolite. For preliminary work, indeed, it is possible to use other methods—the off-set method, for instance—with great success; but when a railway is formed, and the question is one of laying the rails to true curve, the theodolite method is the only reliable plan in practice. When, therefore, the writer of the present paper took the subject in hand, he made it a first consideration that no curve should be adopted which had not the property of being readily set out by theodolite; and the character of the curve and the form of the tables have all been suited to the above condition.

With regard to the necessity for such a curve, the writer takes that for granted. It is notorious that sharp curves are systematically "eased off" at the springing, in order to lessen the lateral shock to a train coming upon them off a piece of straight, but this very remedy may easily prove harmful, except the "easing off" is carried a long way up the curve, for it is clear that a curve cannot be flattened at one point without being rendered sharper at some other point; and if, as mostly happens, the curve is flattened at the springing without a careful adjustment of the curve for a long distance up, then a dangerous kink is left in the curve; and the writer has seen engines run off the line for this very reason. Various attempts have been made to ease off curves on a system; the curve of sines and the curve of adjustment have both been applied to the purpose; but neither of these curves is adapted to setting-out by theodolite, and the inconvenience of setting-out curves with poles on a railway nearly finished—and it is at that time that it has to be done—when the work is going on, and the way is much blocked with materials of all sorts, is almost intolerable, and renders any method of this kind quite impracticable.

The curve which is adopted in the present paper, together with the tables, was communicated to the writer by the Astronomer Royal; for the application of the curve nothing is assumed beyond the ordinary data, viz., two straight lines and the angle they include; the appended tables will then give all the elements required for laying down the curve on the ground, and for computing its length, etc., as may be necessary.

The curve is the cubical parabola whose equation is

$$y = \frac{x^3}{a^2}$$

The chief advantage of this curve is that it hugs the tangent very closely for a long distance after leaving it, and thus the change of curvature is at first very gradual—which is the object in view. It has also the advantage of being the simplest curve of its class, and, by reason of the high powers involved in the expansions which occur when dealing with the properties of the curve, very close approximations are arrived at in very few terms of the series.

The denominator a^2, in the equation above given, as an arbitrary constant; and its value assumed for the formation of the present tables, $a^2 = 400$, has been chosen from the following considerations. Among the properties of the curve, it will be found that the radius of curvature decreases from infinity at the commencement of the curve, till it attains a minimum value at a point for which,

$$x = \frac{a}{\sqrt[4]{45}}.$$

Now, it is assumed that in setting-out railway curves, the ordinary unit of measurement will be the chain, and that, in general, the minimum radius of curvature allowed will be 10 or 11 chains; these, then, have been selected as conditions proper for determining the form of the curve, and the value of a^2, which has been adopted, will be found to produce a minimum radius of curvature = 11.3. It must, however, be observed that the foregoing assumptions merely fix the general shape

of the curve, and do not in any way restrict the use of the curve to the precise conditions which were assumed in order to determine a suitable value for the constant; it will be at the option of the engineer to fix the minimum radius of curvature which he will admit, and the tables can then be used at once to set out the curve, so as to have that minimum radius of curvature, with this provision, that if the minimum radius of curvature which he adopts be other than 11.3 chains, he must work with a different length than the chain as unit. The method of fixing the unit and applying the tables will be seen in the examples below.

The tables are adapted to the method ordinarily pursued in setting-out circular curves; the successive unit lengths are chained along the curve, and the angles set off from the tangent by means of the theodolite. In ranging the curve, since the minimum radius of curvature is reached at a certain definite distance, in terms of the unit, from the tangent point, it may happen that this distance is less than half the length of the curve; in this case the curve is supposed continued with a circular curve of the said minimum radius until the half curve is completed, and the other half of the curve is ranged in the same manner from the other tangent point. There is no calculation involved in the above arrangement, but the necessary angles are taken out of the tables continuously and without interruption.

It may be well to describe the process to be followed in a given case. The first thing is to determine what shall be the sharpest curvature allowed, as this will fix the unit of measurement; the next thing will be with the known angular change of direction (this will be the same as the exterior angle between the tangents), to take out of Table I. the distance of the ends of the curve from the intersection of the tangents, in units of the length already determined; and thirdly, the theodolite must be planted at one of these points, and the half-curve ranged in successive unit lengths by the angles given in Table II.; the same must be done for the other point, and the curve is ranged.

Thus, for example, let the angular change of direction be 50 deg. and let it be determined to fix 15 chains as the minimum radius of curvature. From Table I. it appears that from an angle of 50 deg. the length of the semi-curve is 8.052. Also from Table II., it appears that at a distance along the curve of 8.0, the radius of curvature is 11.4. If, therefore, it be intended that this minimum radius of curvature shall represent 15 chains, the unit of length must be taken at $\frac{15}{11.4} = 1.31$ chains; in other words, the unit must be a chain of 131 links.

Referring back to Table I., it appears that for angle 50 deg., the distance of the theodolite station from the intersection of the tangents is 8.456, or, using the proper unit, is $8.456 \times 1.31 = 11.08$ chains; and if this distance be measured along both tangents it will fix the two ends of the curve.

The theodolite may now be planted at one of these points, and the half curve ranged by means of the angles given in Table II., using throughout a length of 131 links as the unit. When half the curve is ranged, the theodolite must be shifted to the other end of the curve for ranging the other half.

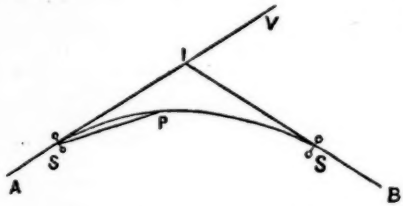
In the above example it has been necessary to make use of a unit adapted to the conditions; but should the conditions be altered, so that the minimum radius of curvature, as found in the tables, and due to the angular change of direction, be not less than 15 chains, then the ordinary chain of 100 links can be used as unit. Thus, let the angular change of direction be 15 deg., then the tabular semi-length of the curve is 4.197, and the tabular radius of curvature due to this semi-length is nearly 16; consequently, the chain of 100 links may be assumed as the unit without fear of transgressing the fixed minimum radius of curvature, 15 chains.

With the foregoing explanation we may proceed at once to the tables:

Let A I, B I, be the two tangent lines which are to be united by the curve, so that V I S, the angular change of direction, is a known angle; then, for the complete setting-out of the curve, we require to know the following elements:

1. The equal distances I T, I S, which define the theodolite stations, T and S.
2. The length of the curve.
3. The theodolite angle P T I, for successive points defined by the meas-

ure of successive unit lengths on the curve.



4. The radius of curvature for several points along the curve.

To supply these elements the two following tables have been computed:

TABLE I.—*Argument: The angular change of direction; giving the distance of theodolite station from intersection of tangents, and length of semi-curve.*

Angular change of direction.	Distance of theodolite station from intersection of tangents.	Length of semi-curve	Angular change of direction.	Distance of theodolite station from intersection of tangents.	Length of semi-curve.
deg.	Chains.	Chains.	deg.	Chains.	Chains.
1	1·076	1·076	52	8·704	8·250
2	1·525	1·525	53	8·829	8·349
3	1·868	1·868	54	8·955	8·449
4	2·158	2·157	55	9·082	8·548
5	2·414	2·413	56	9·211	8·647
6	2·646	2·645	57	9·340	8·746
7	2·860	2·857	58	9·471	8·846
8	3·058	3·055	59	9·603	8·945
9	3·245	3·241	60	9·737	9 044
10	3·424	3·417	61	9·872	9·143
11	3 594	3·586	62	10·008	9·243
12	3·758	3·748	63	10·146	9·342
13	3·914	3 902	64	10·285	9·441
14	4·066	4·052	65	10·4.6	9·540
15	4·214	4·127	66	10·568	9·640
16	4·357	4·337	67	10·712	9·739
17	4·497	4·475	68	10·858	9 838
18	4·633	4·607	69	11·005	9·937
19	4·767	4·736	70	11·154	10·037
20	4·899	4·864	71	11·305	10·136
21	5·028	4·988	72	11·458	10·235
22	5·155	5·110	73	11·612	10·334
23	5·280	5·229	74	11·769	10·434
24	5·403	5·347	75	11·928	10·533
25	5·596	5·463	76	12.089	10·632
26	5·647	5·577	77	12·252	10·731
27	5·766	5·689	78	12·418	10·831
28	5 885	5·801	79	12·586	10·930
29	6·003	5·911	80	12·756	11·029
30	6·120	6·019	81	12·929	11·128
31	6·237	6·127	82	13·104	11·228
32	6·353	6·233	83	13·:82	11·327
33	6·468	6·339	84	13·463	11·426
34	6·584	6·444	85	13·647	11 525
35	6·699	6·547	86	13·833	11·625
36	6·8'3	6·650	87	14·023	11·724
37	6·9 8	6 753	88	14·216	11·823
38	7·043	6·855	89	14·412	11·922
39	7·159	6·955	90	14·612	12·022
40	7·274	7·057	91	14·815	12·121
41	7·389	7·157	92	15·022	12·220
42	7·505	7·257	93	15 232	12·319
43	7·622	7·357	94	15·446	12·419
44	7 739	7 457	95	15·665	12·518
45	7·857	7·556	96	15 887	12·617
46	7·975	7·656	97	16·114	12·716
47	8·094	7·755	98	16·346	12·816
48	8·214	7·854	99	16·582	12·915
49	8·335	7·953	100	16·823	13·014
50	8·456	8·052	101	17·070	13·113
51	8·579	8·151	102	17·321	13·213

TABLE II.—*Argument: Measure from Theodolite Station along the Curve: giving Angle at the Theodolite, and Radius of Curvature.*

Measure from theodolite station along the curve.	Angle at the theodolite.			Radius of curvature.
Chains.	deg.	min.	sec.	Chains.
0·25		0	30	
0·50		2	10	
0·75		4	50	
1·00		8	40	66.7
1·25		13	30	
1·50		19	20	
1·75		26	20	
2·00		34	20	33·4
2·25		43	30	
2·50		53	40	
2·75	1	5	0	
3·00	1	17	20	22·4
3·25	1	30	40	
3·50	1	47	30	
3·75	2	0	30	
4·00	2	17	0	17·0
4·25	2	34	30	
4·50	2	53	10	
4·75	3	12	40	
5·00	3	33	10	14·0
5·25	3	54	0	
5·50	4	17	10	
5·75	4	40	20	
6·00	5	4	20	12.3
6·25	5	29	20	
6·50	5	55	0	
6·75	6	21	30	
7·00	6	48	50	11·4
7·25	7	16	40	
7·50	7	45	10	
7.75	8	14	20	
8.00	8	44	0	11·4
8·25	9	14	0	
8·50	9	44	40	
8·75	10	15	30	
9·00	10	47	0	11·4
9·25	11	18	30	
9·50	11	50	30	
9·75	12	22	40	
10·00	12	55	20	11·4
10·25	13	28	0	
10·50	14	1	0	
10·75	14	34	10	
11·00	15	7	30	11·4
11·25	15	41	10	
11·50	16	14	50	
11·75	16	48	50	
12·00	17	22	50	11·4
12·25	17	57	0	
12·50	18	31	20	
12·75	19	5	40	
13·00	19	50	20	11·4

PILES placed in the Rhine by the Romans, nearly 2,000 years ago, have been found to be entirely sound when removed within the present century.

CHIMNEYS.

The chimney of the West Cumberland Hæmatite Iron Works is deemed by Professor Rankine worthy of an extended paper before the Institute of Civil Engineers in Scotland, not because it is new or extraordinary in design, but because it is a successful example of the application of correct principles and good workmanship. We extract the following particulars :

	Feet.
Height above the ground line	250
Depth of foundation below the ground line (including a layer of concrete 3 ft. deep)	17

	Ft.	in.
Inside diameter at top of cone	13	0
" " at 2 ft. above bottom of cone	21	10
" " of basement	18	10
" " of archways for flues	7	6
Outside diameter at top of cone	15	3
" " at 2 ft. above bottom of cone	25	7
Outside dimensions of square basement	30 ft.	× 30 ft.

	Ft.	in.	Ft.	in.
Outside dimensions of foundation course	31	6	× 21	6
Outside dimensions of concrete foundation	34	6	× 34	6

The change from the square to the octagonal shape in the basement is made gradually by stepping the brickwork at the corners. A straight batter was used in preference to the theoretically correct curved batter, because the former could be tested by the eye.

The duty of the chimney is to carry off the gaseous products from 4 blast furnaces and various stoves and boilers—say from 10½ tons of fuel per hour.

It had previously been ascertained, that in order that a round chimney in this windy region may be sufficiently stable, its weight should be such that a pressure of wind of about 55 lb. per square foot of a plane surface directly facing the wind, or 27½ lb. per square foot of the plane projection of a cylindrical surface—that is to say, a pressure equivalent to the weight of a layer of brickwork 3 in. deep, and of an area equal to the vertical section of a round chimney—shall not cause the resultant pressure of any bed-joint to deviate from the axis of the chimney by more than one-quarter of the outside diameter at that joint. By calculating according to that principle the thicknesses of brickwork in the cone were determined to be as follows :

Uppermost	80 ft. of height	1½ brick.
Next	80 ft. "	2 bricks.
"	88 ft. "	2½ "
Lowest	2 ft., increasing by steps from 2½ to 4 bricks, in order to spread the pressure on the basement. The bed-joint of least stability is 2 ft. above the ground line. The thickness of the arching in the openings for flues is three bricks. The following are the intensities of the mean pressures due to the load on different bed-joints :	

	Tons on the Square foot.
At 2 ft. above the ground line	8
In basement at the springing of the arches	3
On the upper surface of the concrete	2
On the ground below	1.6

The thickness of brickwork already stated, include the fire-brick lining, whose thicknesses are as follows:—In the uppermost 160 ft. of the cone, half brick; in the lower part of the cone, the basement, and the flue archways, one brick. The fire-brick lining is bonded with the common brickwork in the ordinary way—the fire-bricks are laid in the fire-clay and the common bricks in mortar. The reasons for adopting this mode of construction in preference to an internal fire-brick chimney are, 1st, the fire-bricks contribute to the stability of the chimney; 2d, unless the internal chimney is carried up to the top of the outer cone, there is a risk of damage through the explosion of inflammable gaseous mixtures in the space between; and, 3d, under the same circumstances there is a risk of the cracking of the outer cone at and near the upper end of the inner cone through unequal heating at that place.

Vertical cracks in a chimney are the more dangerous the higher the level at which they occur, because the safety of the higher part of a chimney depends more on cohesion and less on weight than that of the lower part. When such cracks take place near the ground, they are of little or no consequence.

The basement is paved inside with 6 in. of fire-brick, resting on 6 in. of common brick, which rests on the concrete.

The ordinary brickwork is built in English bond; in the basement there is one course of headers to every two courses of stretchers; on the cone, one course of headers to every three courses of stretch-

ers. Strips of No. 15 hoop iron, tarred and sanded, are laid in the bed-joints of the common brickwork cone at intervals of 4 ft. in height, with their ends turned down into the side joints. In the concrete foundation, the basement, and a small part of the cone, the mortar was made of hydraulic lime; the mortar for the rest was made of a pure lime rendered artificially hydraulic by a mixture of iron scale in the following proportions :

Lime	2 measures.
Scale	1 "
Sand	5 "

The principal constituents of the iron scale are probably silica and protoxide of iron, but its action upon lime, and the nature of the artificial cement which it forms, have not hitherto been investigated by chemists.

On the top of the chimney is a pitch-coated, cast-iron curb, 1 in. thick, coming down 3 in. on the outside and inside. The lightning conductor is a copper wire rope, about $\frac{3}{4}$ in. diameter. It terminates in a covered drain, in which there is always a sufficient run of water.

In the construction of the internal scaffolding care was taken that the horizontal beams should be supported wholly by the brickwork, and not by the upright posts; for great danger has been known to arise from the brickwork coming to bear upon the ends of the needles, and through them on the posts, owing to the settlement of the lower part of the chimney.

In order that the concrete foundation might have time to harden before being subjected to a heavy load, it was made by the Iron Company themselves before the contract for the chimney was let; for it is known that intense pressure tends to retard the hardening of concrete. The progress of the building was restricted by the specification to a rate not exceeding 6 ft. of vertical height per day.

The work was executed by Messrs. Wm. Wilson & Son, Glasgow. The estimated cost was £1,672; the actual cost, including designing and superintendence, £1,560; being at the rate of almost exactly fourpence per cubic foot of the whole space occupied by the building, which is 94,000 cubic feet nearly.

According to the latest account, the temperature inside the chimney, when doing about three-fourths of its full duty, is 490° Fah.; and the pressure of the draught is $1\frac{7}{8}$ in. of water, which agrees to a very small fraction with the pressure as deduced theoretically from the temperature and the height of the chimney.

The dimensions and stability of the chimney which has just been described are nearly the same with those of the second highest chimney at St. Rollox Chemical Works, built about ten years previously, except that in the older chimney the joint of least stability is 100 ft. above the ground.

In the great St. Rollox chimney, 445½ ft. high from foundation to top, the greatest pressure of wind which can safely be borne is almost exactly the same. The bed-joint of least stability is 210 ft. above the ground. In the great Port-Dundas chimney, 468 ft. high from foundation to top, the bed-joint of least stability is 200 ft. above the ground; and the greatest safe pressure of wind is 67 lb. per square foot of a plane surface, or 33½ lb. per square foot of plane projection of a cylindrical surface, so that there it may be considered that there is an excess of stability.

One of the richest and most ornamental of modern chimneys is connected with the new India mill, Dorwen, Lancashire. The total height of the chimney shaft from the bottom of the foundations to the top of the iron cresting is 310½ ft., and from the ground line 300 ft. The base is of solid ashlar, 29 ft. square at ground line, and 42 ft. high. The stone cornice to the base is 35 ft. long on each of the four sides. The shaft itself is built with red, white, and black bricks, with sand grit-stone dressings, and is 24 ft. square, and built perfectly plumb. The walls are 3 ft. thick at top of stone base, reduced by "offsets" on the inside to 23 in. at the commencement of main cornice, which is 255 ft. above the ground. Many of the stones used in this cornice weighed as much as 5 tons each, and were hoisted by steam power. The balusters surmounting this feature are of cast-iron, as also are portions of the 4 vases at the corners. The crown mould of the cornice at the top of the shaft projects more than three times as far over the wall as it rests on it, and was kept in its place by iron cramps until the cast-iron cresting was fixed upon it. This cresting contains about 20 tons

of metal, and is composed of more than 300 castings. There is no bolting nor any particle of wrought-iron in this portion of the work, the parts being kept together by slots and lugs. The whole weight of this cresting stands upon the brickwork, and keeps the upper stone cornice firmly in position. There is an interior and totally independent shaft, 180 ft. high, to prevent the great heat from the boiler furnaces subjecting the wall of the outer and main shaft to unequal expansion and contraction.

MODERN ARCHITECTURE.

THE OFFICE OF ART IN ENGINEERING.

It may be stated, as a general rule, that whatever in construction—in engineering construction even—is true and suitable and proportioned to strains and service, is also beautiful; or if this statement is too broad, it will not be denied that those structures in which material is utilized and power is applied to the best advantage, are the most beautiful and pleasing. This is as true of a connecting rod as of a cathedral. The art element should therefore be considered in engineering, on professional grounds as well as in the general interests of civilization and refinement. In architectural construction, and in all great or conspicuous engineering works, the want of farther ornamentation and balance of parts may often appear after the strains and functions are all provided for, but it will nevertheless be found, when "artistic effect" is *stuck on* by an afterthought, that both truth and taste have been violated. The artistic element must be associated with the design from the beginning. The following extracts from an article entitled "Modern Architecture—the Philosophy of Failure and the Secret of Success," are from "The Building News":

It will be admitted by intelligent observers of all schools that modern architecture regarded from an art point of view is not a success. We have huge edifices, triumphs of engineering skill, imposing piles of building resplendent with tropies of the stone-carver's craft, and magnificent erections of iron and glass, marvellous as specimens of metalwork, and gorgeous in their effect. Nevertheless we have no distinctive and satisfactory style, no precise principle of construction, no characteristic method of ornamentation, and no practical power of realizing that idea of *beauty* which hovers in thought before the mind of every intelligent designer.

It may seem but the repetition of a hackneyed truism to assert that the *true* and the *beautiful* are inseparable. Yet if we are not greatly deceived it is because in modern architecture these two qualities are regarded and treated as separable that the practice of art is a failure. As a matter of fact the attainment of beauty is proposed as an object altogether apart from the consideration of truth.

The architect who designs his building on a purely utilitarian principle, trusting to his ingenuity to make it beautiful by a subsequent process of ornamentation, is practising an æsthetic fraud. His edifice is not beautiful in itself, he is conscious of its defect; hence he labors to give it a meretricious aspect by means of ornament. Is it wonderful if he fails? Again, the designer who distorts the constructional parts of his work with the aim to realize something of beauty is no less untruthful, inasmuch as the ornamental feature, the façade or the tower he contrives to produce, are not necessary—they form no integral part of the utile edifice. The public eye quickly detects the artifice.

In illustration of these supposed classes of work, and in proof that they are not imaginative, it is only necessary to instance the numberless hotels, stations, warehouses, and public buildings scattered throughout the country which in themselves are ugly, but to the perverted vision of a vitiated taste are made tolerable by an incrustation of cornices, carved friezes, statuettes, intricate metalwork and elaborate ornament. These are examples of buildings erected without a thought of beauty and beautified afterwards. The class of works which are untruthful in their form, and ape beauty rather than possess it, may be illustrated by the 12 or 14-roomed houses fashioned like castles, the insurance offices and banks built to resemble edifices of great civic importance. The cloistered bath and wash houses, the club houses and reading rooms, like Greek or Roman temples, the divans like ducal palaces, and the parish churches in town and country constructed as cathedrals—all these things are *deceptive*, and it is because they

transgress the principle of truth and regard the attainment of beauty as an object to be gained apart from truth, and even in violation of its immutable and universal laws, that they are failures.

Among the examples of works designed in neglect of the principle of truth, Silesbury Cathedral is mentioned; its chief defect is weakness. The violation of engineering truth at once impairs the artistic effect.

It is a task of great difficulty to define the precise conditions of architectural truth. On the first blush of the matter it is self-evident that there must be purity of intention in the design. If a man sets out with the purpose of building a barn, it must not be a Swiss villa or a Chinese joss-house that he plans—it must be a barn pure and simple. The practical error takes its rise in the false notion that certain objects are more respectable and pleasing than others, and, falling into the vicious practice of flattery, the architect deems it more complimentary to the feelings of his client or considerate to public taste to make his barn look like something very charming, light, and graceful. Now, truth would forbid all such misrepresentation of fact, and would interdict all meretricious ornament. It would require a grandeur, and a style and degree of ornamentation, befitting the nature of the building and the purpose to which it was to be applied, but it would not allow the enrichment of a plain mass with a view to raise it to the pitch of beauty supposed to be possessed by a building of more elaborate figure. This was the principle on which the designers of the best and purest epochs in the history of art acted. The works which have been preserved for us from the thirteenth century are eminently *truthful* in their intention. They tell the story of their use without disguise or prevarication. They do not seek to appear more noble or higher in the scale of beauty than they are placed as respects the arrangement, configuration, and balance of the masses of which they are composed. The ornament is never excessive, it never belongs to a class of building more elevated or elaborate than that to which it is applied; it never suggests the idea that the designer aimed to make his work look *enriched* or beautified. Simplicity and truth are characteristics of a style which all accept as thoroughly honest and pre-eminently respectable.

The error into which the Gothic revivalists have fallen is that they have attempted to produce the *form* of mediæval work but neglected the *spirit*. Now it must be evident that much of the architecture which we admire in its place, amid the associations of the thirteenth century, would be anachronic, however skilfully reproduced in the nineteenth century. What we want is a revival of the old spirit of manly outspoken honesty and the love of truth which animated the old art-architects. Special developments of art are inseparably connected with conditions of time, place, and circumstance. We cannot live, and dress, or build as they did who lived in the thirteenth century, but we can subject ourselves to the same pure and simple influences of truth which swayed their minds.

MANAGEMENT OF SMALL TUBULAR BOILERS.

Under the head of management of portable engine boilers, a correspondent of "The Engineer" gives some useful information on this subject. The boilers referred to are of the locomotive type. The cylinders are usually at the fire-box end, and the exhaust pipe passes inside or outside the barrel to the blast nozzle. The feed-water enters the boiler in some cases through the tube plate of the barrel, but more generally through the underside of the barrel near its front end.

For washing out the boiler there are generally 7 mud holes, 1 at each corner round the bottom of the fire-box, and 1 at the bottom of the smoke-box tube plate; the number and position of these holes are very inadequate to the thorough cleansing of the boiler from the dirt and impurities which enter with the feed-water, and which, if not constantly and easily removed, soon fill it with incrustation; the parts that suffer most from this great enemy to all boilers are the water spaces and stays around the fire-box, and among the tubes in the neighborhood of the feed-pump, the greatest amount of incrustation being formed in the front water space of the fire-box where no mud holes exist. To remove the deposit from this space, the best plan is to cut a mud hole in the outer plate at a short distance

below the tubes, and as near the middle of the plate as practicable; by this means the dirt which drops down from the tubes is easily removed. One or two additional mud holes arranged in a higher position round the fire-box shell, would also prove of great assistance in keeping the stays free from corrosion.

In the neighborhood of the feed-pump, and immediately opposite the orifice in the boiler, incrustation is rapidly formed among the tubes; so much so, that the spaces between them, and even the feed orifice itself, become sometimes completely choked with dirt. The consequence is, that the water delivered by the pump not having free admission to the boiler, causes shortness of water and constant breakage of the working gear. For cleaning this part of the boiler, a plan I have generally adopted with success is to fix a 2-inch gun-metal plug at the side of the smoke-box tube plate and clear of the tubes, directly in a line with the feed orifice; by occasionally removing this plug and introducing a rod, the incrustation which forms round the feed orifice is broken up and falls to the bottom of the barrel, whence it is removed through the existing mud hole. It is also well to fix a half-inch plug in the side of the feed-pump valve box, immediately opposite the delivery orifice in the side of the boiler. A rod introduced through this hole will always keep the delivery pipe free from corrosion. To still farther prevent the accumulation of dirt, it will be found a good plan to draw a few tubes periodically—say, half-a-dozen on the feed side; by this means the incrustation formed among them can be quickly and completely removed. A good boiler-maker will draw these tubes without damaging them, and they can then be put in again; but even if 1 or 2 of them fail and require renewing, the expense of the new tubes is soon saved by a decrease in the consumption of fuel consequent upon a clean barrel. I have generally found it to be further advisable at the end of 12 months, if the boiler has been pretty regularly worked during the time, to draw all the tubes, and by sending a boy through the manhole into the boiler, the water spaces and barrel can be thoroughly cleaned, and the tubes, which become coated with a hard scale, can be scraped, and renewed where damaged or burnt. At the same time all leaky stays round the fire-box should be drilled out and replaced by stays of S. C. iron.

The expense of these operations is fully compensated for by the increased efficiency and durability of the boiler.

The joints about a portable engine boiler next demand attention. These are a constant source of trouble and expense. In cases where the exhaust pipe passes through the boiler, the flange joints in connection with the cylinder eduction ports in the top plate of steam chest are continually failing, and the steam entering the leak causes a continual blast through the exhaust pipe, and a great loss of steam. In breaking and making these joints afresh, the screws which secure them, and which are tapped into the base of cylinders, break short off inside the boiler; the consequence is that the cylinders have to be lifted and the screws renewed, which is a very expensive and tedious job. A great improvement is to substitute studs for screws, with nuts inside the boiler. In some portables where the exhaust pipe passes along the top and outside the boiler, this leakage is avoided.

Failure often takes place in the joint or bedding of the cylinders on the boiler, the base or flange of the cylinders not being properly brought to a true bearing on the crown plate. This joint is well made with wire gauze, and red and white lead, but an equally good, if not better, joint is made with iron borings and Scotch cement.

Leakage is constantly taking place among the tubes, and among the bolts and studs connected with the boiler, viz.: —The fire-box bridge bolts, the cylinder and saddle bolts, and the studs securing the fire-bar bearers to the sides of box. Excessive leakage in the ends of the tubes is a sure sign of an accumulation of dirt behind the tube plate; this dirt being first removed, the tubes can be made tight by judicious caulking; continual caulking, however, is very injurious to the tubes and plate, and whenever this fails, the ferule should be withdrawn and replaced by one slightly larger in diameter. A good grummit for the heads of the fire-box bridge bolts is made of spun yarn, with a thin coating of Scotch cement; leakage in the saddle bolts is not easily remedied; being put in from

the inside of boiler, great difficulty is experienced in reaching them. The fire-bar bearer studs are not made strong enough for the weight they have to carry, and when leaky are very troublesome; the best plan is to replace them by larger screws of S. C. iron.

It is almost unnecessary to add that the water-gauge cocks, the blow-out cock, and safety-valve fittings, require constant looking to, and should be always kept free from corrosion and in good working order.

It cannot be too often impressed upon engineers in charge of steam-boilers, that the great desiderata for their safe and economical working are :—careful enginemen, good and constant supply of pure water, entire freedom from dirt and corrosion, and tightness in every part; by a proper and systematic attention to these points a boiler can always be kept efficient and safe from accident, and will last for years.

Painting Zinc. — A difficulty is often experienced in causing oil colors to adhere to sheet zinc. Boettger recommends the employment of a mordant, so to speak, of the following composition :—One part of chloride of copper, 1 of nitrate of copper, and 1 of sal-ammoniac, are to be dissolved in 64 parts of water, to which solution is to be added 1 part of commercial hydrochloric acid. The sheets of zinc are to be brushed over with this liquid, which gives them a deep black color; in the course of from 12 to 24 hours they become dry, and to their now dirty gray surface a coat of any oil color will firmly adhere. Some sheets of zinc prepared in this way, and afterwards painted, have been found to entirely withstand all the atmospheric changes of winter and summer.

Cement for Steam and Gas Pipes.—The following directions are given for making cement impermeable by air and steam, which is said to be superior to any in use for steam and gas pipes :—Six parts of finely-powdered graphite, 3 parts of slaked lime, and 8 parts of sulphate, are mixed with 7 parts of boiled oil. The mass must be well kneaded until the mixture is perfect.

NEW THEORY OF PUDDLING.

THE AGENCY OF CARBONIC ACID GAS.

Mr. John F. Bennett, of Pittsburgh, who has taken a patent for the use of carbonic acid gas in the Bessemer converter —a process about to be tested in Sheffield, we understand—writes at length to the "Iron Age" (Dec. 3) on a kindred subject. After quoting Dr. Percy's theory of puddling, which has been the received theory of all writers from Kane in 1835 to Fairbairn in 1865, he objects to it in detail, and states his own views with at least considerable plausibility. The following are the points in the case :

The only air that enters the furnace passes up through the grate bars of the fireplace, and is wholly changed into carbonic acid gas. As there is not enough air to consume all the combustible matter, part of it passes off as distilled gases, and part of the carbonic acid gas is decomposed into carbonic oxide gas; in both cases not giving out their value, and so causing waste of fuel and loss of heat and time. The writer built a puddling furnace which is now in successful operation, into which is drawn, immediately beyond the fire bridge, a quantity of hot air equal to one-third of what passes through the grate bars. This scarcely suffices to burn all the combustible matters. In the Silesian gas puddling furnaces the supply of air is exactly proportioned to the combustible gases. So also in the Siemens' furnace. But if free oxygen did pass over with the unconsumed combustible gases, and would combine with carbonic acid sooner than with iron, how much rather would it prefer the gaseous carboniferous matters amongst which it is infused, to the partially liquid iron on the bed of the furnace, against the surface only of which it could impinge. Therefore, there is, practically, no free oxygen influencing the action in the puddling furnace.

With regard to the blue flames of carbonic oxide gas issuing from the surface of the molten metal, produced by the reaction between the carbon of the pig-iron and the oxygen of the oxidized compounds of pig-iron, as Dr. Percy states—these blue flames of carbonic oxide gas must have some other origin, inasmuch as the protoxide of iron in the puddling furnace cinder is increased at each operation, and not decreased, as would be the

case if Dr. Percy were correct; also it is unknown in chemical reactions that the oxygen of the protoxide of iron can be removed by carbon. Nor will oxygen combine with carbon to form carbonic oxide gas so that it can be exhibited, for although carbon does undoubtedly unite with its equivalent oxygen to form carbonic oxide gas in the first instance, when they come together at the proper temperature, yet such is the affinity of carbonic oxide gas for oxygen, that at the moment of its formation, it combines with it and forms carbonic acid gas—or, in other words, if 1 atom of oxygen was present with 1 or more atoms of carbon at the proper temperature, carbonic acid gas would be produced and might be exhibited, but if 2 atoms of oxygen and 1 or more atoms of carbon were present, carbonic acid gas alone would be produced and exhibited; therefore, practically, oxygen burning with carbon would produce only carbonic acid gas, and not the well-known blue flames of carbonic oxide gas as exhibited in the puddling furnace of the iron works, or the black ash furnace of the alkali works. Therefore, says the author, the process of eliminating carbon from iron in the puddling furnace is not assisted by the oxygen of any part of the cinder, or of the oxidized compounds of iron added during the process.

Mr. Bennett's theory is as follows: On the bed of the puddling furnace we have molten pig-iron, consisting of iron, carbon, sulphur, phosphorus, silicon, manganese, aluminum, calcium, magnesium, etc., played over, surrounded, and permeated with hot carbonic acid gas. That portion of the atmosphere of carbonic acid gas that permeates the liquid pig-iron may be looked upon as liquid, thus allowing free play for chemical affinities to display themselves as readily as they do when different salts of hydrogen are dissolved in water and commixed. In the order of their affinity, the silicon and carbonic acid first combine, depositing carbon in the molten pig-iron, while the silicic acid is evolved as a gas in part and deposited in the liquid cinder in part. Co2x=Cx2 Si. O. While this operation is going on there is an increase of carbon in the molten pig-iron as shown by the experiments of Calvert and Johnson and M. Lan.

The carbonic acid next combines with the carbon forming carbonic oxide, which is evolved as a gas. Co 2 xC=2 Co. The carbonic acid next combines with the sulphur, depositing carbon and evolving sulphurous acid and sulphuric acid, which is in most part retained in the liquid cinder as sulphate. The carbonic acid next combines with the phosphorus, depositing carbon and evolving phosphorus and phosphoric acid, which is in most part retained in the liquid cinder as phosphate. The carbonic acid next combines with the manganese, depositing carbon and evolving manganous acid, which is in most part retained in the liquid cinder as protoxide. The minor impurities of magnesium, calcium, aluminum, etc., are removed in the same manner.

That this is substantially the order in which these impurities are removed may be shown in the action of the blast furnace, where, when these are the impurities of the iron ore smelted, if the manganese is deposited in the slag, so are the sulphur and phosphorus, while if the manganese remains in the pig-iron, so do also the sulphur and phosphorus. While these three last operations are going on, the carbon deposited is also acted upon by the carbonic acid and evolved as carbonic oxide gas.

While all these operations are going on, the iron is also acted upon by the carbonic acid, carbon deposited, and ferrous acid in part evolved as a gas and in part deposited in the liquid cinder as protoxide. While the action is taking place between the carbonic acid and the following substances, viz., silicon, carbon, sulphur, and phosphorus, both being hot, say 3,000° Fahrenheit, there is no diminution of temperature. When the action begins to take place between the carbonic acid and the iron, there is a deficiency of temperature manifest, and the iron begins to be pasty and capable of being agglutinated together, and so collected into balls, this deficiency of temperature being caused by the temperature of the carbonic acid being only 3,000° Fahrenheit, whereas pure iron requires a temperature of 5,000° Fahrenheit to become liquid, and in the action of the transfer of oxygen from one metal to another there is no heat made apparent; or, in other words, the heat lost by the taking away of the oxygen of the carbonic acid is at the same time restored by its combination with the iron.

NEW EXPLOSIVE AGENTS.

Compiled from the "Pall Mall Gazette."

NITRO-GLYCERINE.—Mr. Alfred Nobel, a Swedish engineer and chemist, was the first to attempt the application of nitro-glycerine as an explosive agent, although it had been known as a chemical curiosity since 1847. His original plan was to impregnate gunpowder with the liquid, thus adding very considerably to the destructive powers of the former. It is a peculiarity of nitro-glycerine that, although it explodes violently when submitted to a sudden and sharp concussion, it is flamed with difficulty by the simple application of heat or fire, and then burns very much like any inflammable, non-explosive liquid. About five years ago Mr. Nobel adopted the ingenious device of accomplishing the main explosion by a small preliminary detonation, by means of the ordinary mining fuze, with a small case containing gunpowder, or a metal cap containing detonating powder, attached to its extremity. Thus the destructive force of nitro-glycerine may be developed with tolerable certainty, no matter whether the liquid is more or less strongly confined.

The possibility of applying nitro-glycerine in its pure state as an efficient explosive agent, in mining and similar operations, having been thus demonstrated, Mr. Nobel proceeded to perfect the manufacture of the material, and to give illustrations in public of its extraordinary destructive powers, which have been estimated at 10 times as great as gunpowder.

The new "blasting oil" was first used in Sweden and Norway, where manufactories were established by Nobel, and subsequently in other countries; notwithstanding the difficulties and dangers to be encountered in the employment of a liquid of uncertain stability, possessed of poisonous properties, horribly dangerous to handle, and having the tendency to solidify at a temperature above the freezing point, when the danger attending its manipulation becomes greatly increased. A succession of the most fearful disasters have occurred during the transport, manufacture, and manipulation of the substance, the first at Colon, and others in New York, California, Australia, and other parts of the world, also two destructive explosions last summer in Belgium and in Sweden (at Nobel's factory). The employment of nitro-glycerine has since been prohibited in the two last-named kingdoms, and the very name of the substance is now everywhere most properly regarded with a feeling of dread, which any modification in the properties of this destructive liquid will fail readily to dispel.

DYNAMITE.—These facts have led Mr. Nobel to contrive a safer modification of the liquid; the result has been the production of "dynamite," a buff-colored powder, somewhat oily or adhesive to the touch. This material is a somewhat crude nitro-glycerine preparation, and consists simply of a silicious earth (or any other inert powder), impregnated with a considerable quantity of nitro-glycerine. A solid, inert substance is thus made the vehicle for the application of the explosive liquid, and the disadvantages which specially attach to the fluid character of nitro-glycerine are set aside. But although nitro-glycerine in this form is safer to transport, and is applicable with more ease and certainty as a blasting agent than the liquid, its injurious influence upon the health of those employing it, and the possibility of its undergoing changes which may result in spontaneous explosion, are not overcome. Moreover, the physical character of dynamite renders it less convenient to handle than gunpowder and other solid explosives; and it is obviously less powerful than the undiluted liquid. Like nitro-glycerine in the pure state, dynamite will not explode upon simple application of a red-hot iron or flame, but if exposed to the effects of a detonation in immediate proximity to it, the violently destructive results obtained with the liquid are developed in proportion by the solid.

NITRO-GLYCERINE AND GUN-COTTON.—Another preparation of this substance has lately been produced by Mr. Abel, Chemist to the War Department, and made the subject of some interesting experiments at Chatham and Woolwich. It is produced either in the form of hard granules, or of discs or pellets of compressed gun-cotton, containing about three-fourths their weight of nitro-glycerine. The nitro-glycerine is thus held absorbed within a porous, solid substance, which is itself endowed with strong explosive prop-

erties. All contact of the nitro-glycerine with the air, and with those handling this preparation, is prevented by a hard impervious coating with which the grains or discs are provided. This material would therefore appear to be decidedly safer and more convenient to handle, transport, and preserve, besides being more powerful as an explosive than dynamite. If lighted in open air it simply burns, without any explosive effect; but when confined it does not, like dynamite or the liquid nitro-glycerine, require a detonating fuse for the development of its explosive power, though its violent explosion, even in open air, may be brought about in that way, just as in the case of the other substances.

Improved Gun-Cotton.—Unfortunately for the interests of nitro-glycerine, a new and valuable addition to our knowledge of gun-cotton, recently made at Woolwich, renders it very doubtful whether the explosive liquid, in whatever form it may be presented, is likely to enter into successful competition with that material. It has been found that the explosive force of gun-cotton may, like that of nitro-glycerine, be developed by the exposure of the substance to the sudden concussion produced by a detonation; and that if exploded by that agency, the suddenness and consequent violence of its action greatly exceed that of its explosion by means of a highly heated body of flame. This is a most important discovery, and one which invests gun-cotton with totally new and valuable characteristics.

Some remarkable results have been already obtained with this new mode of exploding gun-cotton. Large blocks of granite and iron plates of some thickness have been shattered by exploding small charges of gun-cotton, which simply rested upon their upper surfaces. Long charges or trains of gun-cotton, simply placed upon the ground against stockades of great strength, and wholly unconfined, have been exploded by means of detonating fuses placed at the centre or at one end of the train, and produced uniformly destructive effects throughout their entire length, the results corresponding to those produced by eight or ten times the amount of gunpowder when applied under the most favorable conditions. Mining and quarrying operations with gun-cotton applied in the new manner, have furnished results quite equal to those obtained with nitro-glycerine, and have proved conclusively that if gun-cotton is exploded by detonation it is unnecessary to confine the charge in the blast-hole by the process of hard-tamping, as the explosion of the entire charge takes place too suddenly for its effects to be appreciably diminished by the line of escape presented by the blast-hole. Thus, the most dangerous of all operations connected with mining may be dispensed with when gun-cotton fired by the new system is employed.

It will readily be observed that this discovery, which we believe is due to Messrs. Abel and Brown, of the War Office Chemical Establishment, is likely to be attended with most important results. It has been said, and said justly, that if you want gun-cotton to exert itself you must coax it into the belief that it has a great deal to do. You must give it bonds to break and physical obstacles to overcome, with no outlet or possibility of escape. But now, gun-cotton will exert itself, and put forth more than what was believed to be its full strength, whether it sees any work to do or not. This discovery, therefore, can hardly fail to lead to the universal adoption of gun-cotton for mining purposes, as soon as its new properties become generally known.

In connection with possible military applications the discovery is invaluable. There can no longer be any doubt what agent should be employed for the breaching of stockades and the like; and the absence of all necessity for the use of strong confining envelopes will have an important bearing upon the employment of gun-cotton for torpedoes and all submarine explosive operations, besides greatly simplifying mining and breaching operations in the field. We have, in fact, discovered several new advantages to add to those which already had sufficed to recommend gun-cotton as an explosive agent in preference to all others.

Isaac Newton, Esq., late Chief Engineer in the Navy, Engineer of the Monitor during her first engagement, and an accomplished scholar in all that pertains to ships, steam, and naval affairs, is associated with Gen. McClellan in the completion of the Stevens battery.

WASTE OF WOOD.

STATISTICS—THE REMEDY—IRON AND CONCRETE STRUCTURES.

From the last report of the United States Department of Agriculture it appears that unless measures are taken immediately to replace by new plantations the supplies withdrawn by the destruction of our old forests, there will be an actual famine for wood in this country within the next 30 years. It is estimated that from 1850 to 1860 no less than 50,000,000 acres of new land were brought under cultivation, of which two-fifths were timber land. And in the decade ending 1870 there will be no less than 100,000,000 acres so reclaimed. In the single State of New York, from 1850 to 1860, there were reclaimed from the forest and brought into cultivation no less than 1,967,433 acres of land. All these acres will never again be devoted to timber growing, and still the destruction goes on.

The great consumption of wood is for building, fuel, and railway sleepers. The value of the farms of the United States in 1860 was $6,654,045,700, while the value of the lumber improvements was $3,322,522,000. All this has been cut from the soil, and most of it within 30 years. Little or nothing has been done to replace it. The sleepers used on the railroads of our country from 1850 to 1860 cost $23,063,957. More than 100,000,000 railway sleepers are now in use, and as these are almost entirely hard wood, and last but 2 to 5 years, it will be seen that the annual supply for this purpose is enormous, and increasing as fast as new railroads are built. In a single year there was used for repairs of railroads and railroad buildings and cars in the United States, no less than $38,000,000 worth of wood.

There are no less than 477,623 artisans in wood in this country. If we estimate the value of their production at the low price of $1,000 each per annum, we have the still greater aggregate of an industry of $500,000,000 per annum dependent solely on wood. It is a noteworthy fact that wood in all its branches of manufacture and use, pays more than one-half the entire internal revenue of the United States, and no less than 66 trades depend upon wood as bare material for their labor. The wood fuel used for locomotives in the United States reached the enormous figure of $56,000,000 in a single year.

Besides the scarcity and increased cost of wood for all these purposes, a more serious loss is likely to result to agriculture, from the greater severity of the climate, due to the loss of the forests. The irregularity and extremes of temperature we now endure, were not formerly known.

These are startling facts, and their importance cannot be too quickly or too seriously considered by governments, communities, engineers, farmers—all men. The people should rise in self-defence, as in case of foreign invasion. Without discussing at this time the proper work of Government in the matter, nor of farmers in replanting and sparing forests for their individual protection, we would urge engineers, builders, and all consumers of wood in great and permanent structures, to renew their efforts to cheapen the other and more plentiful materials of nature, and more especially to *avoid the use of perishable wood.* In the majority of cases the use of wood costs more in the long run than stone, brick, cement, iron. Decay outruns interest.

Wooden railway bridges do not pay anywhere, and wooden sleepers are not found to pay in many countries where this material is peculiarly scarce and perishable. Iron sleepers, with a small amount of wood in pockets, to give the necessary elasticity, are really permanent and safe, and would be economical to-day on lines of heavy traffic in our Eastern States. The wear and tear of rails and rolling stock directly due to the decay and the cutting and mashing of wooden sleepers, the cost of their renewal every five years, and the better support and increased bearing of the rail obtainable with iron, are all sound and weighty arguments in its favor. Because simple stone blocks were found too rigid, the idea of stone permanent way seems to be entirely discarded. But where stone is plentiful and easily wrought, the placing of wooden pockets in large blocks of it would cost little more than wooden sleepers, and be sufficiently elastic.

Excepting only wooden shipbuilding, the most unreasonable and not the least extensive use of wood is in the floors of great stone and brick city houses. Prob-

ably three-quarters of the very first class and most costly buildings erecting in our cities, have wooden floors. The first cost of iron is certainly a great temptation to avoid it; but higher rates of insurance and inevitable destruction by fire at some time, will eat up the saving. If wood and iron were of equal price, the permanence of the latter should warrant its adoption in all the better class of buildings. There is some reason and hope in legislation on this subject. When a man's wooden-floored warehouse is gutted by fire, the verdict is, "served him right." But when this conflagration lights the warehouses of his neighbors, they have a rightful and should have a legal claim against him. For farm buildings and country houses brick should be more generally adopted as an economical measure; the repeated painting and inevitable decay and reconstruction of wood cost more in the end. Concrete is getting into larger use, especially abroad; it is cheap and permanent. This subject will be more fully referred to in another article.

What engineers and builders have to do is to *cheapen* brick, concrete, artificial stone, iron, and the modes of moulding them into houses and structures. The wood question is so positively alarming, that a great demand—a rush—is likely to be made in the new direction, and every improvement will be gladly and widely welcomed. We know of no business likely to be more remunerative than the production of a cheap mineral building material, on a large scale.

As to wood fuel, the grand consumption of locomotives and steamers is already much abridged. The charcoal furnace is a great destroyer of forests, and we look to the improvement in coal furnaces—high and large stacks, better hot blast, better fluxing, and the purification of ores and of irons in subsequent treatment—to lessen the necessity and the demand for charcoal-iron.

It is singularly fortunate that the material we want so much to preserve, is the material we ought so little to use. Wood in heavy and exposed structures, and especially when subjected to wear, is utterly perishable. It immediately begins to depreciate in strength and value, and its short life is but a series of paintings, patchings, splicings, and repairs. For this reason it is after a short service not only unreliable, but so yielding as to decrease the service and durability of surrounding parts. If this is not enough, the injury to agriculture by the destruction of forests, should be enough to warrant every public and private effort to preserve them. The cultivated taste of the times has found nothing more suitable for furniture and decoration than the natural woods, and whatever of this material can be spared from the hill sides can be advantageously employed for these and similar purposes.

In the West this subject is better understood than among us, and laws have already been passed in Iowa, Kansas, Missouri, and other States, looking to the growth of forests, such as the exemption of made and natural wood growths from taxes. And the timber nurseries of the West are already vast in extent. In some parts the first thing the farmer does is to plant the fast-growing cotton wood, and the next is to plant better wood to take its place. In the East, where timber has been more plentiful, and is soon to be more scarce than in the West even, and where more durable building materials are more cheaply produced and more needed, the subject has not received proper attention.

How to Lay out a City.—The "New York Times" argues that the right-angular plan has turned out as inconvenient as the cow-path system, and advocates for situations like New York, a main longitudinal avenue of great width, with rectangular and diagonal streets leading from it. There should certainly be some other means of getting from corner to corner of a series of square blocks, than going round the town or "playing a game of checkers" through its centre. Diagonal streets may yet have to be cut through our right-angled cities. Baron Haussman has spent 375 millions in altering the map of Paris, during the last fifteen years.

Power Looms were first constructed in England by Cartwright in 1787, and first started in this country on the improved plans of Moody, an American, by Lowell (after whom the city of looms was named) in 1815.

COMPRESSED SLACK COAL.

Mr. Warington W. Smyth's report on the art of mining and metallurgy at the Paris Exhibition.

Within the last few years, careful experiments, conducted by the administration, have proved, what was long doubted, that France possesses coals excellently adapted for sea service; and for some time past no other than French coal has been used in the Imperial navy. But for these purposes the fossil fuels from different localities have to be judiciously selected and mingled in certain proportions. Taking the coal as a whole, it is noticeable that it makes much more small and dust than our own, and is more frequently apt to be "dirty" or mixed with shale and clay. It hence results, that the French coalmasters have been driven to pay a special attention to methods of cleaning their produce and utilizing the "slack," *menu*, or small coal. At the great Exhibition in 1851, Bérard's coal-washing machine came before us as a novelty, although it was only in certain details that it could rightly be so considered; and, besides several contrivances for that purpose introduced more recently, a great variety of ingenious apparatus has been brought into use for making "patent fuel," *agglomeres*—that is, for pressing the small coal into cakes of various forms by the aid of a small amount of some binding material. These *briquettes* are highly reported upon for naval use; in their carriage to the ports there is a loss of only 1 per cent., against from 6 to 10 per cent. on lump coal; and when stored abroad they are found after two years' exposure scarcely at all injured, whilst ordinary coal would have suffered to the extent of 50 per cent. Moreover, they are free from ash, and may be made of a mixture of flaming and of dry coal, or of those varieties which have a more free-burning and a more calorific property respectively, in such a ratio as to give the best effect in getting up and maintaining steam. The late Exposition abounded with examples of the machinery and the products of this manufacture; and, although we are not in Great Britain without a similar industry, attention may fairly be called to the subject in the interest of the millions of tons of small coal and of inferior qualities which we are every year actually getting rid of as refuse.

As early as 1833, Messrs. Marsais and Ferrand took out a patent for this purpose, but it was not until 1843 that the agglomerated coal began to be produced in any quantity, and some more years elapsed before the machinery was so far improved by several different engineers as to lead to the present large scale of the manufacture. The St. Etienne Company, by introducing an enormous hydraulic pressure, need only to add 5½ per cent. of pitch (*brai sec*) to solidify the mass. The stack of rectangular blocks left outside the St. Etienne shed in the "park," throughout the heavy rains in April, gave good testimony to the thorough compactness and durability which had been thus attained.

The greater part of the French makers appear to have adopted the circular arrangement of the Messrs. Revollier, and of Mr. Evrard and M. Dehaynin.

In this machine the cylinders are disposed as the radii of a circle, in which the slack, after being heated by a current of steam, and mingled by very ingenious apparatus with the pitch, is pressed by pistons and formed either into cylindrical or hexagonal blocks of convenient length. The rate of production appears to be in practice, 10 tons per hour with one machine, requiring an engine of 50-horse power to work it, and the extreme limit of pressure being 100 atmospheres.

The prices of the St. Etienne compressed fuel are high; the first quality, which contains only 2.10 per cent. of ash, is marked at 28 francs per ton; the second, with 5 per cent., at 26 francs; whilst the best block coal rules at from 19 francs to 23½ francs, and the small at 9½ francs to 15½ francs. The very small proportion of gas, tar, or pitchy matter introduced into the mass at this work, can scarcely be considered as a general guide, since different qualities of coal will need some more and some less of binding material.

M. Felix Dehaynin, a producer of no less than 175,000 tons of *agglomeres* in the year, exhibited drawings of the Evrard machine as modified by himself, and employed at his three works, in which 500 people are engaged. The company called the "Ocean," at Paris, were also exhibitors of drawings and of the apparatus for the same purpose, known

by the name of its inventor, M. Mazeline.

As an adjunct in these operations, an ingenious machine by Hanrez & Co. may be noticed. It is constructed for the dying of small washed coal by the revolution of a screw within a revolving perforated cylinder, and is stated to dry five tons per hour.

We could wish that coalworkers, mineral landowners, and capitalists, would note these various indications of what is now becoming in France an important trade. Without being unmindful that several companies have been established in South Wales and elsewhere for a similar manufacture, we cannot but be conscious that their action is but an infinitesimal set-off against the wholesale waste of slack that takes place in this country. It is not only that the small coal cut and broken from the salable part of seams is, in most of our districts, thrown into goaf and gob by the tens of thousands of tons, but those proportions of beds, often some feet in thickness, which are intermixed with stone or sulphur, or which make a larger than usual proportion of slack, are at once rejected as useless, and acres of such coal are abandoned to be inextricably mixed up with broken roof and heaving floor, although of no worse quality than would be turned to advantage in many a French colliery. It is impossible, in the hard competition of the times, to blame individuals for this sin against the economical use of Nature's gifts; but it is a discredit to the country at large, and will, among our descendants, entail many an anathema on the selfish stupidity of their forefathers. American miners take notice.

Electro-Plating iron with copper and brass is successfully carried on in France, in the following simple manner: —The iron object is coated with a varnish of resin, dissolved in benzine. This is then coated with plumbago, and the copper deposited as usual. By this means the peeling off of the thin layer of copper is obviated.

Saw Works.—Disston's in Philadelphia comprise 7 buildings, having an area of 500,000 square feet, and employ 400 hands.

THE INSTITUTION OF CIVIL ENGINEERS.

HISTORY OF THE SOCIETY—ITS NEW HOUSE IN LONDON.

Compiled from "Engineering."

Former Societies.—Although the Society of Arts was founded in 1754, the English engineers had no representative body, no arranged and adequate means for the communication of ideas, till much later. In 1768 Smeaton and a few friends formed a more or less convivial engineering club which met at the Queen's Head Tavern in Holborn, and lasted some 20 years, but left no professional records. In 1792 Smeaton was about to reorganize the society in a "better and more respectable form," but his death prevented. His friends, however, did reorganize it, and commenced a series of fortnightly meetings on April 15, 1793, at the Crown and Anchor in the Strand; there was better order, but not less eating and drinking. The "Smeatonian Society of Civil Engineers" still exists, and holds monthly meetings at the Freemason's Tavern during Parliamentary sessions, but its pith and sap have been absorbed by its single vigorous branch, the "Institution of Civil Engineers."

History of the Institution.—In 1817 William Maudslay, Henry B. Palmer, Joshua Field, James Jones, Joshua Collinge, and James Ashwell, formed a society and drew up rules which are still maintained with some modification. In 1821, Thomas Telford, appreciating the value of such a society, and foreseeing how it might extend in professional influence and power if well managed, accepted the presidency. In his inaugural he said that the institution had arisen from the wants of society, and being the result of its present state promises to be both useful and lasting. Under the able guidance and powerful influence of Telford the society grew and prospered. Its meetings were held at No. 1 Cannon Row, Westminster, till 1839, when it erected its present offices, No. 25 Great George Street. On the 3d of June, 1828, it obtained a royal charter, and was incorporated under the title of the "Institution of Civil Engineers." Telford's devotion to the interests of his protégé increased, as he gave up professional pursuits in his later years, and he remained president till his death in 1834. The second president,

Walker, retained the chair for 10 years, and Sir John Rennie remained in office 3 years. The term of presidentship is now 2 years, and since Rennie, 11 members have filled the chair. At the present time the institution has 1,689 members, of whom 16 are "honorary," 641 "members," 909 "associates," and 123 "students."

New Building—Cost.—The insufficient accommodation of the old house led to inquiry as to the best site and plans for a larger building. An eligible site and structure in Victoria Street would have cost £26,000 to meet which the institution had the rent of the old house, £4,000, and £18,000 available property; this would have entailed a debt of £4,000. The old site, 25 Great George Street, sufficiently increased by the purchase of adjoining property, was therefore obtained at a yearly rental for 99 years of £659, with the privilege of purchase within 10 years for £12,000. The cost of the alterations and extensions of the building was £11,650. The architect is Mr. J. H. Wyatt; the contractors Messrs. Holland & Hannem.

Main Features — Rooms. — The main feature of the new design was the construction of an ample meeting room in place of the old cramped and awkward theatre 44 feet 9 inches by 24 feet 8 inches; the improvement of the library, and some means to avoid the undue crush of the annual conversazione. At the same time, the old façade and entrance were to remain. The original plans (see "Engineering," vol. V.) were reconsidered, and the present building is as follows:

On the left of the main hall is the secretary's room 24 by 17 feet, and a clerk's office 17 feet 7 inches by 15 feet. The two are separated by a glazed partition which can be removed upon occasion. At the end of the main hall, which is paved with tesselated marble, an archway under the main staircase, decorated with bronze gas standards and statuary, leads to the lobby leading to the council room, 21 feet 6 inches by 31 feet 10 inches, on the left, and the members reading and writing room, 40 feet by 28 feet 4 inches, on the right, and to the lavatories. On Tuesday evenings tea and coffee are served on a removable counter in the reading room, and on conversazione nights the partition between the reading and the council rooms will be removed, making a spacious refreshment room. At the back of the council room stairs lead to the kitchen below, and other stairs to the rear of the president's chair in the theatre above. In the basement, approached by a separate staircase, is the strong room, 12½ feet by 7 feet.

The Theatre.—The main staircase, 4 feet wide, occupies a rectangular well 18 feet 6 inches by 21 feet, extending unbroken to the lantern above, 48 feet from the ground level. A rise of about 14 feet brings up to the level of the meeting-room or theatre on which the principal care of the architect has been expended. It has a clear area of 60 feet by 40 feet, with a height of 30 feet from the floor to the springing of the dome by which the room is lighted. There are four entrances, the doorways of which are handsomely executed in oak. The principal entrance opens from a 6-foot landing at the head of the main stairs, which also extends to the library. A second access is obtained on the extreme left, by a gallery, and is intended for the entry of members who arrive after the proceedings have commenced. On the right two more doors open from another gallery.

The arrangement of the seats in the theatre has been carefully devised. The President's chair occupies a point opposite the space between the central doorways, and from this, as a centre, a series of semicircular platforms have been laid, each tier from the council table to the opposite wall rising above the other, so that the outer row is about 3 feet from the ground. The objectionable plan of having a clear avenue down the centre of the room to the President's chair, a plan which invariably interrupts the attention of the meeting by the entry of late members, has been avoided. The circular benches, arranged upon the platform tiers, are placed 2 feet 7 inches apart from back to back, so that ample sitting accommodation is provided for 375 people, which the room is calculated to hold without a gallery. There is a small room at the back of the theatre, devoted to the use of diagrams, etc.

The sides of the meeting-room are treated with Doric and Ionic pilasters, terminating in sufficiently enriched cantilevers and cornices at the ceiling. The bays left between the pilasters will ultimately be filled with the pictures be-

longing to the Institution. At present, however, the only decorations will consist of brackets carrying the busts which adorned the old building. The principal of these is the marble bust of Telford, which will fill a conspicuous place in the library. Of the others, the main ones will be the portraits of Dr. Olinthus Gregory, Thomas Tregold, Professor Faraday, Sir Robert Peel, John Smeaton, Watt, Rennie, the Stephensons (father and son), Maudslay, the elder and younger Brunel, Locke, John Fowler, Hawkshaw, Joshua Field, Bryan Donkin, G. P. Bidder, and Rendel.

Lighting.—Eight lunettes—4 on the north and 4 on the south side of the meeting hall—aid the light thrown by a large central dome 19 feet in diameter, enclosed in an outer dome, so that the light is passed through a double medium. By night the theatre is illuminated by 3 sunlights; the central one in the middle of the dome has 63 lights, and the 2 side ones 28 lights each. Two grated openings are provided in the ceiling for ventilation.

Heating.—Thirteen grated openings placed around the room about 15 inches above the floor, and openings in the risers under the seats, admit the warmed air forced from the basement at the rate of 400,000 cubic feet per hour, being an allowance of 800 cubic feet per hour for 500 people. Fresh air is taken from without and carried along an underground channel leading into the basement. At the extremity of this channel a fan, driven by a 1-horse gas engine, forces the air into a chamber, where it is warmed in winter, and can be cooled in summer. The apparatus employed for warming the air consists of a series of hot water pipes, 4 inches in diameter, disposed in horizontal tiers, and so arranged that the entire volume of air used for ventilation must be passed amongst the spaces between them before it leaves the chamber. The axis of the fan used for forcing the air into the building is situated parallel with that of the air channels, and it carries two blades placed at 50°, the diameter being 3 feet. Means have also been provided for filtering the air before admitting it, and in summer a cold water spray will be forced against a fine wire gauze screen covering the mouth of the channel to cool the air on its passage. Valves are placed in the different branches to regulate the admission, and an independent coil is placed in the hall to warm the entry to the building.

Library.—In the library, 42 feet by 28 feet, the first and second floors of the old building have been thrown into one, and a gallery supported on brackets, is carried around the room at the old upper floor level; this gallery is wide enough to contain bookcases and leave space enough for stools and desks for readers. The library is illuminated with two 28-burner sunlights, and sufficient ventilation is secured by gratings in the ceiling. The top floor has been made into one spacious loft with an excellent light for the preparation and storage of diagrams.

Such is the house the Institution of Civil Engineers has built and garnished for itself in the fiftieth year of its life.

The Park Bank.—This showy, and in many respects splendid structure, occupying part of the site of the old museum opposite the Astor House, was opened in December. The façade is of white marble, richly decorated in the classic style. The striking features are the double rows of columns supporting the portico, the collossal statuary, and the lofty Mansard roof. The central hall, 12 ft. wide by 50 ft. long, leads to the banking-room, 56 by 90 ft., and 40 ft. high at the springing of the glass and iron dome. The decoration of the walls is Pompeian, and the effect of the warm tints is pronounced very fine. At the 4 corners are 4 medallions representing Art, Science, Industry, and Justice. The wainscoting is 5½ ft. deep, with stiles of dove-colored marble, and panels of reddish Tennessee marble. The screen is of bronze, with black marble shelves and plate glass windows. The desks and counters are of mahogany. The safes cover a space 20 by 7 ft., and are 13 ft. high. The room is warmed by a steam pipe running along the bases of the internal divisions, and a number of Gold's heaters. On 3 sides of the room are galleries 8 and 10 ft. in width; from 1 of them opens the book-room, 50 by 9 ft.; from another, the directors' room, 24 by 17 ft., decorated like the banking-room, and richly furnished. On the right of the main hall is the bank parlor, 48 by 20 ft., and 17 feet high. It is velvet carpeted, walnut-root wainscoted, Marcott deco-

rated and furnished, and altogether princely. The space on the other side of the hall, and in the 2d story of the front building, is divided into spacious rooms for other banking and insurance companies.

The safety deposit vault in the basement of the building is built of granite blocks 2 feet thick, and contains 486 safes. The foundations of it form a mass of masonry 49 by 24 feet in plan, and 24 feet high. The front foundation wall of the building is 32 feet deep below the sidewalk, and from 8 to 11 feet thick. A 3-horse power caloric engine in the basement forces water 95 feet high to a 3,000 gal. tank. The building is essentially fire-proof. The floors are iron girders and brick arches.

The building cost $700,000; the lot $350,000. The architect is Mr. G. H. Thomas; the builder, Mr. G. T. Smith; the carpenters, Messrs. Smith & True. The statuary is by Mr. R. E. Launitz.

LOCOMOTIVES FOR HEAVY GRADES.

The system of locomotives for the Mont Cenis Railway is thus commented upon in "Engineering." The construction of a railway over Mont Cenis, to be worked until the completion of the great tunnel, was a work creditable in every way to English enterprise and engineering skill. But we cannot the less disapprove of the absurdly complicated system of locomotive power employed to work in it.

The gradients on this line are 1 in 12, and the gauge 3 feet 7 inches. Messrs. Fell and Alexander, engineers, have respectively reinvented and worked out the old Vignoles-Ericsson-Sellers system of mid rail and engines with gripping wheels —a scheme as needless as a fifth wheel to a coach. These engines have frequently broken down, and it has been sought to throw the discredit upon the French makers, MM. Gouin who are among the very first makers in France, whose work —and they have made nearly 1,000 locomotives—gives no trouble on other lines.

It is now understood that a totally new class of engines will be made for the Mont Cenis line by MM. Cail & Co., the eminent locomotive constructors of Paris and Lille. The horizontal wheels are to be connected by spur gearing, and so driven by independent cylinders; whereas, in the present complicated plan, the 4 coupled driving wheels and the 4 gripping wheels are worked from a single pair of cylinders. The new engines, which have been designed by Mr. J. R. Crampton, will certainly be superior to those now on the line.

But our authority concludes the gripping wheels and mid rails unnecessary, for the following reasons: Inclines of 1 in 18¾ had been regularly worked for 6 years on the Virginia Central Railway, the engines drawing from twice to three times their own weight behind them. Inclines of 1 in 10 had been worked during the winter of 1852–53 on the Baltimore and Ohio Railway, the coupled engines, having the whole of their own weight available for adhesion, drawing a load equal to their own weight behind them. At the opening, too, of the Mont Cenis Railway, last summer, the engine went up with its train, drawing its assigned load by the adhesion due to its own weight, the "gripping wheels" not being put in action at all.

It is quite certain that the adhesion of the driving wheels on a clean rail is often from one-fourth to one-third, and in some well-attested cases even three-eighths of the weight, and it is abundantly capable of proof that an engine or steam carriage, with its whole weight and load available for adhesion, can ascend inclines of 1 in 12 in any and all weathers.

THE NITRATE STEEL.

The controversy regarding the Heaton process has overrun the columns of the engineering press, into the London "Times." The only conclusion we are able to draw from the great mass of matter published, is that Mr. Heaton's claim to have made soft, uniform, homogeneous rails and bars, without remelting the first product of the converter, conflicts with the chemical possibilities as we now understand them. Says "Engineering:" The highest chemical authority in the kingdom, Professor Miller, has analyzed the Heaton metal, from samples taken by himself direct from Mr. Heaton's converters and rolling mill, and has found, as was to have been expected, numerous and extensive impurities, which unmistakably indicate not only a variable, but a very inferior, if not worthless quality. One sample of "crude steel" had almost

3 per cent. of impurities, of which 1.8 per cent. were carbon. Another sample of this steel after it had been simply cut, piled, heated, and rolled, had nearly 2 per cent. of impurities with 1 per cent. of carbon. Any so-called steel made from highly phosphuretted pig, by a hasty boiling over nitrate of soda, including the incorporation into its own mass of a lump of cast-iron at the moment when the nitrate floats to the surface, could not possibly be expected to be uniform in quality, nor could it be expected to be of good quality in any case. A correspondent of the same paper says: The secondary or resultant product obtained by merely cutting, piling, beating, and hammering while in a spongy state, appears to have a wonderfully different chemical composition, one-half of the carbon being removed. This, it is tolerably certain, would not be the case with any other steel. A puddled steel, a crucible steel, or a Bessemer steel bar contains as much and no more carbon than the bloom, blister bar, or ingot from which it was made. But the secondary product of the Heaton process, although it is asserted to contain 1 per cent. of carbon, is nevertheless pronounced to be "malleable iron of the finest and purest quality." As to the authorship of the process, the authority first quoted says: Nor is Mr. Heaton even the inventor or discoverer of the use of nitrate of soda for purifying iron. He has invented merely a mode of using it, whereby it was kept or supposed to be kept at the bottom of the metal charge until the oxygen of the nitrate is given off. He first places the nitrate in the bottom of his converter, and to prevent it from at once floating to the top when the charge is poured upon it, he fastens it down by a cast-iron plate perforated with holes to allow the melted iron to obtain access to the nitrate, and to allow the oxygen thus evolved to rise.

This authority, however, does not attempt to *write down* the new process, but farther says: Mr. Heaton may be quite sure that his experiments in making steel from common brands of iron are watched with the greatest interest, and, so far as the iron trade is concerned, with all the hope that is possible in the face of so much conflicting evidence. If his assertions are true, he will, by another year, have added at least ten millions to the value of the iron now made in Great Britain, taking the value of his professed improvement at £2 10s. a ton only on 4,000,000 tons. His mode of treating melted pig-iron is much more expeditious than puddling, his plant is inexpensive, and the alleged increase of value of iron treated by his process is even greater than we have just estimated. A report to the Austrian government by Mr. Fred. Kohn takes an unfavorable view of the Heaton process, and in the matter of cost, states as follows: The difference between the price of phosphoric pig-iron and of pig-iron which is comparatively free from phosphorus, is about the same as the price of the nitrate of soda; it is therefore obviously simpler to purchase the dearer pig-iron, and to produce really pure steel from it, than to purify the inferior pig-iron in a certainly very incomplete manner, and to spend for the chemicals employed for this purification the whole balance derived from the difference in the prices of good and bad pig-iron.

The points in Mr. Bessemer's letter to the London "Times" are: 1st.—The inference to be drawn from a previous comparison of Heaton's and Bessemer's processes in the "Times" is that Mr. Heaton can by his process produce, from a cheap and inferior pig-iron, steel of a similar character to that obtained from a more expensive raw material by the Bessemer process. That is, however, far from being the case, for Bessemer steel is cast-steel—that is, steel made into a perfectly homogeneous mass while in a fluid state—and to that circumstance alone owes its great value as a material for the manufacture of railway bars, etc. 2d.—Whenever solid substances are converted into gas, a vast amount of heat is absorbed and rendered latent; hence in the Heaton process so much heat is abstracted from the metal in generating oxygen gas by the decomposition of nitrate of soda that the metal solidifies while in a state of mechanical admixture with the sand and soda, and thus, instead of obtaining fluid cast-steel by his process, Mr. Heaton obtains only a lump of spongy, porous metal, intermixed throughout with slags and scoria, and having the general characteristics and properties of ordinary puddled-iron or puddled-steel, but which is only obtained at a cost (for nitrate of soda)

of more than double that of the ordinary puddling process. 3d.—The Heaton crude metal may, in common with puddled-iron of every description, be made into cast-steel by resorting to the old and costly Sheffield process of melting in crucibles, a process which consumes about 3½ tons of coke for every ton of metal so melted, and with the additional cost of wages, crucibles, etc.; this melting process alone costs from £5 to £6 per ton. Hence, although Mr. Heaton starts with a cheap pig-iron, giving him an advantage of 20s. to 30s. per ton over the cost of the Bessemer raw material, he nevertheless employs for the conversion of 1 ton of pig-iron (according to Dr. Miller's report), no less than 270 pounds of nitrate of soda, which, at the present market price of 15s. per cwt., is equal to 36s. on the ton of crude iron, thus bringing up the cost of the materials employed in making 1 ton of crude steel by the Heaton process several shillings per ton above the cost of the high-class iron used in the Bessemer process; and we must add to the cost of the Heaton crude steel the additional cost of £5 to £6 per ton for melting.

In Mr. Heaton's reply the points are: 1st.—His plant is very cheap compared with Bessemer's. 2d.—The cooling effect Mr. Bessemer refers to is far outbalanced in his own process by the cooling effected in his converter by the prodigious volume of cold air forced through it for from 20 to 40 minutes. Which will carry off most heat, such a volume of air, or the oxygen evolved from 224 pounds of crude nitrate to the ton of steel? 3d.—Mr. Bessemer says his steel is a solid homogeneous mass, entirely free from scoria or other impurities, whereas mine is not, owing, he says, to the "mechanical admixture with the sand and soda." This is not the case. The slag, owing to its small specific gravity and to its extreme fluidity, rises to the surface of the molten metal, leaving the subjacent steel free from slag or scoria. It is not the fact that sand is necessarily employed; but were it so, the proportion of alkali is so great that the slag formed would be, and is, perfectly liquid, and is not mixed in any sensible quantity with the mass of steel in the converter, upon which it floats, as I have already observed. 4th.—As to the statement that "Heaton obtains only a lump of spongy porous metal, intermixed throughout with slag and scoria," he says: Steel from my converters passes at once either into my patent reverberatory furnace, or into a furnace of Mr. Siemens, and is kept in a molten state and thence run into ingots, as homogeneous and to the full as good as Mr. Bessemer's. Mr. Bessemer knows that his own steel has been proved by Mr. Siemens to be greatly improved by being thus kept for some time in fusion after it has been poured out of his converter as Bessemer crude steel. It is, therefore, not a fact that my "crude metal can be made into cast-steel only by resorting to the old and costly Sheffield process of melting in crucibles." 5th.—With reference to the nitrate employed: But the circumstances under which the experiments of Dr. Miller were carried on were purely exceptional, and the proportion of nitrate usually employed is not, as Mr. Bessemer states, 270 pounds, at a cost of 36s., but 224 pounds, at a cost of 28s. 6d., taking the extraordinary high prices of nitrate that at present prevail. Ten per cent. of nitrates is all that I have found necessary for the production of a ton of steel from inferior brands, and considerably less than 10 per cent. for superior brands. 6th.—As to quality, Mr. Heaton says: I have but just turned out 40 tons of steel rails direct from my converter, without any re-melting, rails of a fine fracture, neither "fibrous" nor "laminated," but quite as homogeneous as Mr. Bessemer's, resisting the ordinary mechanical tests for steel rails, and produced at a cost with which no Bessemer steel can compete. Further, such orders are in course of execution.

To which Mr. Bessemer replies in another long letter to the "Times," substantially this: Heaton's apparatus is less perfectly developed, and therefore less costly, but 10 per cent. on the cost of the Bessemer apparatus does not amount to over 2s. per ton on the steel produced. As to the cooling action of the air, the heat actually produced in the Bessemer vessel is the most intense known in metallurgical operations. That the Heaton metal is not produced in a liquid state, and has therefore to be melted by another operation, in order to be as sound and valuable as Bessemer's, viz., *steel*, is officially stated by Dr. Miller in his report, and by Mr. Heaton. The former says, the product of the converter was

poured on the floor in a pasty state, and then broken up and melted in pots. Mr. Heaton mentions, in his cost sheet, £5. 10s. per ton for remelting in crucibles. He also told Mr. Bessemer, as a reason why he should not be proceeded against as an infringer of the Bessemer patents, that he did not produce ingots of fluid steel by his (Heaton's)process. Mr. Bessemer admits that his own process could not make good steel from Cleveland iron, but states that the 65s. and 70s. pig that he does use, makes cheaper steel than the cheapest Cleveland pig + 28s. per ton for nitrates.

As to the invalidity of the Heaton patents for the use of nitrates, Mr. Bessemer replies at great length, citing some old patents;* and stating that he was himself the first to make steel by purely chemical means—by simply passing oxygen through the molten iron without the use of fuel, and that his patents claim the use for this purpose, of any oxygen-bearing substance. Mr. Bessemer says he has recently obtained patents for means of using the nitrates, in order to protect himself from farther inroads by Mr. Heaton.

Some tests have recently been made by Mr. Kirkaldy on a steel said to be Heaton's, the result being very uniform, and showing 23 tons tensile strength and 20 to 28 per cent. elongation in breaking. Mr. Heaton states that a remelted tool steel in one-half inch bars, from very impure Cleveland pig, stood above 53 tons. Some of the London authorities do not believe that these tests were made on the Heaton steel. Mr. Heaton's statements conflict with other statements previously published by witnesses of the process, and by the analyst of the product. Until the doubts thus thrown upon the process are explained away, it is impossible to believe that Mr. Heaton has as yet made any great advance in the manufacture of cheap iron and steel. We do not think, however, with some of our contemporaries, that the process is of no value because ironmakers have not yet taken it up. It is also possible that there is value in the nitrates as purifying agents. If so, it should appear that Mr. Bessemer's mode of applying them, described in the last number of this magazine, is more reasonable and hopeful than Mr. Heaton's.

*See Van Nostrand's Magazine, Vol. I., No. 1, page 77.

ENGINEERING IN THE MISSISSIPPI VALLEY.—General Roberts, U. S. A., sets forth in a remarkable paper, that the dyking of the Mississippi is obstructing the creative laws of delta bottoms, by emptying into the Gulf the material that if spread over the land would improve its quality and raise its level. He proposes to feed the Mississippi from the great Lakes, by way of the Rum River and the Illinois River, and connecting canals, and to feed the Ohio from Lake Erie, by way of the Beaver River.

THE MONT CENIS TUNNEL.

PROGRESS OF THE WORK—ENGINEERING DIFFICULTIES—THE BORING MACHINES.

Perhaps no work ever undertaken by men was more daring than the attempt to pierce the Alps with a tunnel. Nature seems to have upreared these mighty barriers as if with the design of showing man how weak he is in her presence. Even the armies of Hannibal and Napoleon seemed all but powerless in the face of these vast natural fastnesses. But the barrier which man had scaled of old, he has now undertaken to pierce. And the work, bold as it seemed, is three parts finished.

The Mont Cenis Tunnel was sanctioned by the Sardinian government in 1857, and arrangements were made for fixing the perforating machinery in the years 1858 and 1859. But the work was not actually commenced until November, 1860. The tunnel—which will be fully 7½ miles in length—was to be completed in 25 years. The entrance to the tunnel on the side of France is near the little village of Fourneau, and lies 3,946 feet above the level of the sea. The entrance on the side of Italy is in a deep valley at Bardoneche, and lies 4,380 feet above the sea level. Thus there is a difference of level of 434 feet. But the tunnel will actually rise 445 feet above the level of the French end, attaining its height at a distance of about 4 miles from that extremity; in the remaining 3¾ miles there will be a fall of only 10 feet, so that this part of the line will be practically level.

The rocks through which the excavations have been made are for the most part very difficult to work, and largely

consist of crystalized calcareous schist, much broken and contorted; through this rock run in every direction large masses of pure quartz. The perforating machines are calculated to work best when the resistance is uniform; and it has often happened that the unequal resistance offered has resulted in injury to the chisels.

But before the work of perforating began, enormous difficulties had to be contended with. It will be understood that in a tunnel of such vast length, it was necessary that the perforating processes carried on from the two ends should be directed with the most perfect accuracy. It has often happened in short tunnels that a considerable but not fatal want of coincidence has existed between the two halves of the work, but in the Mont Cenis tunnel any inaccuracy of direction would have been fatal to the success of the work, since when the two tunnels should meet it might be found that they were laterally separated by two or three hundred yards. Hence "it was necessary," says the narrative of the official survey, "to prepare accurate plans and sections for the determination of the levels, to fix the axis of the tunnel, and to 'set it out' on the mountain top; to erect observatories and guiding signals, solid, substantial, and true."

When we remember the nature of the passes over the Cenis, we can conceive the difficulty of setting out a line of this sort over the Alpine range. The necessity of continually climbing over rocks, ravines, and precipices in passing from station to station, were as nothing when compared with the difficulties resulting from the bitter weather experienced on those rugged mountain heights. The tempests which sweep the Alpine passes—the ever-recurring storms of rain, sleet, and driving snow, are trying to the ordinary traveller; how terribly they must have interfered with the delicate processes involved in surveying. It often happened that for days together no work of any sort could be done, owing to the impossibility of using levels and theodolites. At length, however, the work was completed, and that with such success that the greatest deviation from exactitude was less than a single foot for the whole length of seven and a half miles. Equally remarkable and extensive were the labors connected with the preparatory works. New and solid roads, bridges, canals, magazines, workshops, forges, furnaces, and machinery had to be constructed; residences had to be built for the men, and offices for the engineers; in fact, at each extremity of the tunnel a complete establishment had to be formed.

According to the latest advices the work proceeds at a rate fully equalling the original expectations of the engineers. Of 12,220 metres—the total length of the tunnel—no less than 8,958 have been completed. It is hoped that the remaining 3,262 metres will be completed early in the year 1871.—*Railway Record.*

With regard to the machines used in driving the tunnel, each is formed of a pair of bars, about 6 feet long, having between them the 3-inch cylinder by the piston of which the boring tool is actuated. The cylinder is not fixed to the frame-bars, but is capable of sliding on them, motion being given to it by a large worm at its hind end, which gears into racks formed on the inner sides of the frame bars. The cylinder is 3 inches in diameter, and its piston has a rod about 2 inches in diameter, there being thus but a comparatively small annular area on the front of the piston on which the air continually presses. At the hind end of the frame-bars of the machine is placed a miniature engine, worked by compressed air — this engine driving, through a bevel gear, a square shaft, which extends nearly the whole length of the machine above the boring cylinder. This shaft, by means of a cam, drives the slide-valve of the boring cylinder, and also gives intermittent rotary motion to the tool, and also the necessary advance to the cylinder as the hole is bored. By an ingenious automatic device, the worm is thrown out of gear when the cylinder cannot advance by reason of the hardness of the rock. Each boring machine weighs about 6 cwt., and as the wear and tear to which they are exposed is very severe, it is found necessary to keep from three to four machines in reserve for each one at work.

The boring bars are of various forms and diameters. The Z and double Z or crown borers are those most used, but for some kinds of rock other forms are found preferable. The holes are generally about 1¼ inch. in diameter. In working through some of the very hard quartz it was found that the shots flew back from the ordi-

nary holes without producing any disruptive effect on the rock, and the plan was therefore adopted of first boring several holes 4 inches or 5 inches in diameter, and then disposing some ordinary holes round these. When the charges in the ordinary holes were fired, the portions of the rock between them and the central hole were blown out, and a cavity thus formed, around which other shot holes were bored. The borers used for the 4-inch and 5-inch holes are of similar form to smaller bars, and, like them, they are worked by the boring machines, but at a slower speed.—*Mining Journal.*

The line is now worked by a temporary railway (referred to in another column) over the mountain. This road is 48 miles long, passing over a summit nearly 6,000 feet above the sea, and has long stretches of gradients of 1 in 12, and curves of two chains radius. The gauge is 3 feet 7½ inches.

LOCOMOTIVES OF THE METROPOLITAN RAILWAY.

Very different types of engines are required on the various lines in, about, and under London, but the conditions do not seem to have been equally well met by the different locomotive superintendents. On the North London, the passenger business is large, but the goods traffic is immense. Trains weighing over 400 tons are frequently run with, and compelled to keep out of the way of passenger trains. All the new engines are designed to work goods and passenger traffic alike, and they are, therefore, of the most powerful class, weighing 43 tons, and fitted with 17-inch cylinders, 24-inch stroke, and caring 160 pounds pressure. They perform their duties admirably, and it is difficult to see how they could be improved upon.

The engines of the underground railway have the Bissell bogies, which appear to answer their purpose very well. Whether it is or is not possible to dispense with bogies it is not easy to say, as the underground line affords very conflicting testimony. The engines of the Midland Company, to work their city traffic, are very similar to the standard type, with the exception that they have 6 instead of 8 weels; but their use has been protested against by the engineers of the Metropolitan line, on the ground that, owing to the comparatively long and rigid wheel base, they injure the permanent way. On the other hand, Mr. Fowler designed 6 coupled engines without bogies to work the St. John's Wood traffic, from which we gather that he did not deem a flexible wheel base essential; these engines, however, are more often found standing in their sheds than running. The Great Western Company, too, have introduced 6 coupled, 4-feet broad gauge drivers without bogies, which work regularly and give satisfaction. All the engines we have named are remarkable for the facility with which they start their trains and the shortness of the distance within which they attain their maximum velocity.

The Metropolitan Extension is worked by 3 different types of engines. One class, weighing 33 tons, has 6 wheels, 4 coupled, 16-inch cylinders, 22-inch stroke, and 5 feet 6 inch drivers. The trailing wheels are placed directly under a large tank, and fitted with Mr. W. B. Adams' radial axle boxes. These engines are used alike by the Great Northern, and the London, Chatham, and Dover Company. Both classes are run with either end leading, and for this kind of work they are not the best. The radial axle box is not well adapted for leading wheels, and the engines oscillate very much when running tank-end first. A greater defect lies in the fact that the tanks are so high that the drivers cannot see over them. This latter evil was felt so severely in the case of the London, Chatham, and Dover engines, that Mr. Martley has recently cut 1 foot or 18 inches off them with great advantage.

The next type of engine has side tanks and 6 wheels, 4 being coupled with 15-inch cylinders, 22-inch stroke, and 5 feet 6 inch drivers. They are good little engines, run steadily, and cost little for repairs; thanks principally to the considerable dimensions given to the machinery, which is unusually heavy in proportion to the diameter of the cylinders.

Lastly, the Metropolitan Extension is worked by small tank engines with outside cylinders, 15 inches diameter, and 22-inch stroke; 6 wheels, 4 coupled, and Beattie's patent boiler and fuel-heating apparatus. They are, in some respects, the best engines on the line. Though small, they get away quickly with their trains, make an abundance of steam, and are essentially more "lively" than any of

their rivals. None of these engines appear, however, to be the best that could be adopted in working this line; they are all too large and heavy for the slow speed adopted on this line. With the exception of short inclines at the ends, the road is nearly level, and according to modern notions, without expressively sharp curves.—*The Engineer.*

ACCUMULATOR COTTON PRESS.

From a paper by Mr. Baldwin Latham, read before the Society of Engineers, Dec. 7.

While the cotton culture in India was in its infancy, the quantity produced was too small to create a demand for any special baling apparatus. Machines were sent out from England, but they were of a very primitive kind. Screw presses, something like those used for making cheese, were contrived. The next step was to work the vertical screws by bevel gearing and a winch. Then, as the cotton trade grew in importance, there was devised a number of inventions and contrivances, some by engineers and others by the cotton growers, whose ingenuity was stimulated by necessity. Levers, screws, and wedges were tried alone and in combination. The use of hydraulic pressure naturally suggested itself for trial, but it was not very successful; no very great power was obtained, and the process by pumping was slow. Gradually, improvements were made in the lever presses, and these were generally preferred. Some of them may be mentioned. A Mr. McComb took great pains to make a good baling machine, and patented several of his improvements. His cotton was forced up by two compound levers, drawn together by a chain worked by hand or steam.

Mason's press had somewhat the same principle of levers, but was worked in a different way. A horizontal engine drove 2 machines, the crank-shaft running right and left from the engine. By gearing, a shaft parallel to the crank shaft was driven at a reduced speed, and by means of right and left-hand screws on these shafts 2 powerful levers were drawn together and forced upwards against the follower of the cotton box. Both these presses are still in favor, and are used in considerable numbers. Hodgart's press embodies a very ingenious combination of hydraulic and lever powers. The process by pumping being in ordinary presses slow, it was here endeavored to reduce the quantity of water necessary to be pumped by having a ram of small area, and by multiplying the power so gained by the levers. This press, at its usual rate of speed, will pack 10 bales per hour, and it is possible to do 14; but this is too severe labor for the men. At the time of the Abyssinian expedition, hay was packed for the troops at the rate of 15 bales per hour; but this was an exceptional and extraordinary speed.

The Bombay Press Company uses Nasmyth's press, which is one of the best that has yet been invented. The pressure is effected by 3 hydraulic rams placed side by side. At the beginning of the stroke, while the cotton is in a pliable state, the power is applied by 1 cylinder only. Towards the end of the stroke, the other 2 rams are also set in motion, the 2 cylinders having been filled with water, so as to save time in pumping when the power is applied to them.

There are in America a vast number of inventions for all processes connected with cotton. Levers and screws, hydraulic and steam pressure, have been combined in many different ways, and with varying success. Wood is more used in America than in England in the construction of machines, and machines so made would not probably find favor elsewhere. Very likely English machines would be condemned there. As one of the incidents arising out of the war, when the Southern ports were shut out from the rest of the States, the blockade runners took over English made presses, and among others some of McComb's, but they found no purchasers. Every other detail of cotton packing is studied by inventors in the States, and the correspondent before referred to, says that there are some fifty different patents even for modes of fastening the baling hoops.

Mr. George Ashcroft has patented a machine in which he obtained the power of hydraulic pressure combined with rapidity. The first and easy pressure on the cotton was rapidly effected by a steam piston, only the final and severe pressure being given by a hydraulic ram. This press worked satisfactorily, and would probably have been pushed to success by the inventor had he not thought of some-

thing better, viz.: the application of the accumulator.

While in theory there is no limit to the force that can be exerted by hydraulic pressure, in practice the difficulties commence at a certain point. A maximum pressure of 2 tons to the square inch has been employed; but then it is necessary to have a large area of ram to obtain the required total, and to get this with 1 cylinder involves practical difficulties, which increase very rapidly with the diameter of the cylinder, viz., the risk of spongy castings and parts inconveniently heavy and difficult to transport. In Mr. Ashcroft's invention, the required area is obtained by placing 3 cylinders with 8-inch rams side by side, and these giving a total area of 150 inches, a force of 300 tons is produced.

The box in which the cotton is pressed is made entirely of wrought-iron, strongly framed, and the upper part of it, where the ultimate pressure is received, is of considerable thickness. This part of the box is planed all over, so as to present a true and smooth surface to the cotton. The doors are made so that 3 of the 4 sides can open. The "accumulator" is of the well known simple kind, consisting of a cylinder and ram, the latter supporting a weight box which moves up and down in guides. The 3 hydraulic pumps of equal size are driven by a pair of horizontal engines.

The mode of working is as follows: The house consists of a ground floor and two floors above. Upon the ground floor are fixed the steam-engine, the pumps, the press, and the accumulator cylinder. The framework of the press reaches through the floor to the top of the chamber above. In the uppermost chamber the loose cotton is stored. On the centre floor are the handles for working the valves. During the whole time of pressing and baling the cotton, the engines and pumps are at work. The accumulator box is forced up with a pressure of less than 1 ton to the inch. The men upon the top floor having placed the bagging in the box, and filled it with loose cotton, which they trample down, the men below push round the revolving boxes (a special feature of the invention), so that the cotton-filled box is over the rams. The boxes revolve upon a strong vertical column, the weight being taken on balls, which rest upon a collar. A portion of the floor revolves with the boxes.

The hooping irons having been placed in recesses at the top of the press, the engineer opens the valve which admits the high-pressure water to the rams. At once the accumulator descends, and the 3 rams of the press ascend, forcing the loose bottom of the box upon the cotton. But as the accumulator descends the pumps being still at work, they, in some measure, restore the height of the water column, and the accumulator ram gently ascends and descends as the water is thus withdrawn and restored. When the cotton is compressed upwards as tightly as the rams can force it, the engineer shuts the valve which admits the water from the accumulator and the pumps, and opens one which admits the water from the differential cylinder. By means of rams of different diameters, the pressure given by the pumps is in this cylinder multiplied. The superior power thus produced forces up the 3 rams, and with them the cotton, the last few inches of the stroke to the ultimate point desired. One of the doors of the box is then opened, the hoops are fastened, and then the other doors being opened, the water in the cylinders is let to waste, and the rams descend. The elastic cotton at once expands into the small distance allowed by the hoops, and with but slight assistance from the workmen the bale tumbles from the box and falls down a shoot to the floor below. Meanwhile the other box having been filled with cotton, it is pushed round into its place over the rams, and is in its turn subjected to the pressure of the water, and so the process is repeated without intermission.

The principle of the accumulator is well known, and for working cranes, opening dock gates, and many other purposes, has been in operation some time. It is probable that sooner or later some one would have applied it to baling presses, but at any rate Mr. Ashcroft has done it, and he only. Among the merits claimed for this machine are the following: The simplicity and smoothness of the process obviates the excessive wear and tear which is unavoidable in machines where the pressure is obtained by levers or screws. The friction on the packing leathers is extremely small. Great uncertainty existed until recently on this point, and all

makers of hydraulic presses differed from each other on the subject. Professor Rankine gave 10 per cent. of the total load as the amount wasted by the friction of the leathers, but the whole question has been most successfully investigated by Mr. Hicks, of Bolton, who by his experiments, which are recorded in his admirable little treatise published last year, proves that the friction of the leathers on an 8-inch ram is about $\frac{1}{200}$ part of the total load, the decimal varying from .003 to .005 according as the leathers are more or less worn, and well or sparingly lubricated.

The revolving boxes are an ingenious part of the machine, and by their arrangement obviously save much time. Twenty-five or more bales can be packed and hooped per hour. In Alexandria the accumulator press is in full operation, and at Bombay also it is exciting much interest among the cotton merchants, some of whom are now in treaty with a view to its adoption there.

THE SUEZ CANAL.

From a letter to the London "Times," by Captain Macgregor, of canoe "Rob Roy" fame, we extract the following interesting facts and impressions: The Suez Canal Company have been fourteen years at work upon their gigantic labor, and they announce positively that the canal will be opened within a year from the present time (November, 1868). The canal is to be 100 miles long, and 328 feet wide (at the water's edge). The depth throughout will be 26 feet in the middle. The direction is nearly north and south, with a few turnings, but no locks or bridges. There will be a slight tidal current along it, but no one can say at what intervals. Already about 50 miles of the cut is filled with salt water, and is traversed daily by numerous small vessels and some steam-launches and mailboats. The sensation of wonder at the prodigious scale of the operations in progress increases day by day as one moves along what seems to be a wide river, with villages on the banks and smoky funnels and white sails on the surface. Of this 50 miles many parts are not wide enough yet for large vessels, and only a small portion is excavated to the full depth. The remainder of the canal is more or less dug out. While some parts are quite dry, others are put under water to moisten the sand; others have great blastings of rocks, and one long section of 20 miles has to wait until the sea is admitted into the great dry basin of the future lake.

The dredging machines are 40 in number, and each of them cost £40,000 (?). They deliver the sand to barges to be carried out to sea, or pile it upon the banks, in some places to a height of 50 feet. The expenses at present amount to £200,000 every month, and the work has already absorbed £8,000,000 sterling.

Port Said, the town at the north entrance of the canal, is built of wood, with wide, straight streets, and accommodates 6,000 people of every nation, but with the Greek and Levantine element largely preponderating. The two long piers that form the harbor are made of blocks of sand, cemented with lime (concrete); each block weighs 10 tons, and there are 25,000 of them.

Ismailia is a pretty town half-way along the canal, which here enters the Lake Timsah. Here the Arabs and their camels and the jackals of the Desert are alongside the steamboats, the whirring lathes and sounding forge-hammers of the company's workshops. A fresh-water canal comes hither all the way from Cairo, and then branches out north and south along the whole extent of the salt-water canal. The sweet-water canal is already a blessing to Egypt. It is from 30 to 40 feet wide, and boats with all sorts of cargoes are towed or sail through it.

During one day a violent gale swept across the canal. To look at the Desert was to see a vast yellow picture of men and camels dimly floating in a sea of sand without any horizon. The quantity of sand, whisked from the plain and cast into the canal-water by a wind like this will be a serious matter to deal with. One ounce of sand per square yard amounts to 500 tons on the whole canal, and the wind sometimes blows in this way for a month together.

At Chaloof I found 14,000 men at work. They labor very hard, indeed, running up the hill with baskets of sand on their heads. About 1,000 donkeys walk in long lines with neat mat baskets on their backs. In curious and close contrast to these simple carriers the mighty power of steam toils

and puffs as it hurls up huge bulks of heavy clay, and it is, perhaps, only in Egypt one could see human and animal power exerted in such competition with steam power. The laborers are sent from all parts of Egypt. They must come, but they are highly paid—from 2 francs to 3 francs a day. Prices, both of labor and of food, have risen very much since the canal has been begun, but the supply of fish has rapidly increased. The salt water canal teems with fish.

At this, the Red Sea end, the works of the canal seem very far behind. The entrance port has all the obstacles of a shallow mouth, soft and shifting sand for bottom, and a crooked irregular tide eddying about in a most puzzling way.

When the passage from the Mediterranean to the Red Sea is open to the world it is intended to tow vessels through by tug boats working along a chain which lies at the bottom of the water. Steamers are not to be allowed to use their own paddles or engines for fear of damaging the soft sloping banks of the canal by the "wash" thus created. The difficulty of towing a vessel of 2,000 tons in this manner when the wind presses her to one side is an objection to which I have heard no feasible answer.

THE ITALIAN TECHNICAL COLLEGE of commerce is now organized, and will be opened immediately under the direction of Signor Farrara, a distinguished Sicilian gentleman, lately Minister of Public Instruction. This institution is chiefly intended for young men destined for the Consular service and for mercantile pursuits. The principal languages of Europe and the East, the various systems of banking, the principles of commerce, of exchange, of book-keeping, and of commercial law will be taught in it. The Venetian Provinces contribute toward its maintenance 40,000 francs a year; the city of Venice, the magnificent Foscari Palace and 20,000 francs a year; the Chamber of Commerce, 8,000 francs; and the Government, 10,000 francs.

THE KIRBY REAPER FACTORY of D. M. Osborne & Co., Auburn, N. Y., comprises 8 large buildings, employs 300 men, and turned out 5,300 reapers in 1868.

WORKING THE SOLAR RAYS.

The possibility—we are inclined on general principles, to say the probability—of utilizing the direct heat of the sun, as proposed by Capt. Ericsson, is the grandest scheme that science has presented to man. It should almost appear that the Creator has laid up a little condensed heat in the coal mines for our use during our school-time; a little condensed milk for our babyhood in science; and that when we are grown and learned, we shall draw power from its original fountain. The facts regarding the heat of the sun, as quoted and developed by Capt. Ericsson, together with the recently acquired and equally startling knowledge, that our garnered stores of power are not as eternal as the hills, render such a conclusion reasonable and hopeful.

Capt. Ericsson has not yet told us *how* he concentrates the solar rays, but promises to do so in due time; meanwhile, the experiments and conclusions referred to are interesting and may be thus briefly stated.

Sir John Herschel's experiments relating to solar heat, were conducted at the Cape of Good Hope. His apparatus consisted of a tin vessel $3\frac{3}{4}$ inches diameter, $2\frac{1}{2}$ inches deep, open at the top, and partially filled with water darkened with ink. This was exposed to the immediate action of the rays of the sun in a stationary position for 10 minutes. The amount of radiant heat communicated was deduced from the increase of temperature of the water during the 10 minutes' exposure to the oblique rays. Owing to changes in the atmosphere, the elevation of temperature was not quite alike at each trial. Adopting the mean, he calculates that, near the earth's surface, the energy of the sun is such that the radiant heat is capable of melting an inch thickness of ice in 2 hours, 12 minutes, 42 seconds.

M. Pouillet's experiments relating to solar heat, like those of Sir John Herschel, had reference only to very low temperatures, the range of the thermometer scarcely reaching 60° C. The apparatus he employed was very similar to that of Herschel. It consisted of a cylindrical vessel of silver, 1 decimetre in diameter and 15 millimetres in depth; but being provided with a close top, it admitted of being fully charged with water, besides

admitting of an inclined position, which permitted the rays to act perpendicularly on the blackened metallic surface. The disadvantages attending oblique action, not to mention the intricate question of *evaporation* during the trial, were thus avoided. A thermometer was inserted in the fluid, and means provided for proper agitation during the trial. The exposure to the sun was limited to 5 minutes, and the elevation of temperature during that brief time formed the basis of all his calculations.

These experiments, although interesting, are not satisfactory, as they deal with low temperatures. The purpose of Capt. Ericsson, on the other hand, has been to ascertain what amount of heat can be developed at the high temperature obtained by concentrating the solar rays, viz., bringing their power to bear on a reduced surface, and to devise the most efficient means for effecting such a concentration of the radiating heat. His experiments made under temperatures varying between 212° and 480°, and continued during nearly a year, tend to show that the problem cannot be solved by 5 and 10 minutes' trials restricted to temperatures some half-dozen degrees above that of the atmosphere. The results recorded by Pouillet, reveal discrepancies pointing to atmospheric influence, which, when properly understood, will modify the conclusions hitherto so confidently drawn.

Regarding the main result of the investigations of Herschel and Pouillet there can be no doubt. A body presenting a square foot of surface perpendicularly to the sun at noon, during summer, will, under favorable circumstances, receive about 5 units of heat per minute. This fact Capt. Ericsson has fully proved by concentrating the radiant heat of sunbeams of various sections from 650 to 5,180 square inches, hence fully 500 times more powerful than the sunbeams to which the "actinometer" and "pyrheliometer" have been exposed.

Investigations conducted only during the *summer* being insufficient to settle the important question, Capt. Ericsson is making a series of experiments this winter, with instruments so contrived that the loss of heat by radiation will be almost inappreciable. It is hoped, therefore, that a satisfactory explanation of existing discrepancies will be furnished. In order to facilitate these investigations, a small observatory has been erected over a building some 60 feet above ground, turning on a pivot by mechanism resembling that of a monitor turret. Still further to facilitate the work, the tables which support the instruments have been provided with mechanism by which they are kept perpendicular to the central ray of the sun during the experiments.

Capt. Ericsson's conclusions as to the power of the sun's rays are as follows: At the high temperature requisite for steam-engines, the heating power of the sun on a surface of 10 feet square will evaporate on an average 489 cubic inches of water per hour, by means of his mechanical contrivance for effecting the necessary concentration. This evaporation demonstrates the presence of sufficient heat to develop a force capable of lifting 35,000 pounds 1 foot high in a minute, thus exceeding 1-horse power.

The mean distance from the centre of the sun to the earth being 214.44 times greater than the radius of the former, it will be found by squaring this sum that 1 superficial foot of the sun's surface must heat 45,984 superficial feet of the earth. In other words, the sun on an equal surface throws off 45,984 times more heat than the earth receives. We are therefore enabled, on the strength of the practical result now positively established, to infer that an area of 10 feet square on the sun's surface developes heat enough to actuate a steam-engine of 45,984-horse power, demanding a consumption of more than 100,000 pounds of coal every hour. But as one-half of the heat conveyed by the solar rays is lost during their passage through the atmosphere and through the apparatus by which the temperature is elevated to the necessary high degree, the actual development of heat, on the supposed 10 feet square of the surface of the sun, will therefore equal the amount of heat generated by the consumption of 200,000 pounds of coal per hour.

In pointing out what amount of mechanical power may be obtained by occupying a Swedish square mile with solar engines, Capt. Ericsson assumes that one-half of the area is set aside for necessary roads, houses, etc., an available area would remain of $18{,}000 \times 36{,}000 = 648{,}000{,}000$ superficial feet on which the

radiant heat might be concentrated. His experiments having shown that the concentration of the solar heat on 100 square feet of surface is more than sufficient to develop a horse power, it follows that 64,800 engines, each of 100-horse power, may be kept in motion by the radiant heat of the sun on a square mile, or that the sun's rays which now waste their strength on the house-roofs of Philadelphia, would be able, if condensed, to set in motion 5,000 steam-engines, each of 20-horse power.

As to practical results Capt. Ericsson says: It is true, that the solar heat is often prevented from reaching the earth. On the other hand, the skillful engineer knows many ways of laying up a supply when the sky is clear and that great store-house is opened where the fuel may be obtained free of cost and transportation. At the same time a great portion of our planet enjoys perpetual sunshine. Capt. Ericsson had at the beginning of the last year constructed 3 different motors, called *solar engines*. One of these is actuated by steam formed by the concentration of the heat of the solar rays, while the other 2 are actuated by the expansive force of atmospheric air, heated directly by concentrated radiant heat. Some of his more recent experimental engines, the working cylinders of which vary from 2 inches diameter to 5 inches diameter with 6 inches stroke, are operated by atmospheric air heated to a temperature of 480° by concentrating the sun's rays; others are operated by steam of much lower temperature generated likewise by concentrating the radiant heat. The speed attained has in no case been less than 100 revolutions per minute, while a regular and continuous rate of 300 revolutions per minute has been reached. The construction of these experimental engines, present no features of special novelty. The mechanism, however, adopted for concentrating and transmitting the solar energy to their working pistons, is peculiar, and at the proper times, plans and descriptions will be published.

Excelsior Machine Works, Chicago.—These works employ 75 men on wood work and wood working machinery. The principal building is 270×60 feet.

The Charleston Phosphates.—The "New York Tribune" of Dec. 19, has an exhaustive article on the history and utilization of this important discovery. The "fish bed of the Charleston basin," so called because of the remains of marine animals found in immense quantities there, crops out on the banks of the Ashley river near its mouth, and on various neighboring rivers, and extends inward 40 or 50 miles. The marl or conglomerate of this basin is already ascertained to be 12 feet deep in some places, and to contain as much as 67 per cent. of phosphate of lime in some instances. Although its existence had long been known, its value was not ascertained till after the war, and even then it was difficult to enlist Southern capital in it. The necessary aid was obtained in Philadelphia, and now 5 companies with ample capital are mining the rock, and manufacturing the phosphates for agricultural purposes. The credit of discovering the value of the deposit, and of persistently calling attention to it, seems to be due to Dr. N. A. Pratt of Charleston.

Temperatures of various substances, superheated steam for instance, may often be conveniently ascertained by the melting points of alloys. The following are the fusing temperatures of various alloys of lead and tin:

Lead.	Tin.	Centigrade.	Fahrenheit.
7 parts.	4 parts.	213°	416°
7½ "	4 "	221	430
8 "	4 "	225	437
8½ "	4 "	232	455
10 "	4 "	241	466
14 "	4 "	252	484
19 "	4 "	262	504
30 "	4 "	274	524
48 "	4 "	275	544
55 "	4 "	289	553

Linseed oil boils at 312.40°.
Lead melts at 319°.

Schools in Chicago.—They are as follows: a high school, 21 grammar, and 6 primary schools, which are public; also some 50 private grammar schools, various Roman Catholic, medical and law schools, and the Chicago University. The number of scholars in the public schools in 1867, was 30,000, the total cost per scholar, $23.84, the number of teachers 401, the value of public school buildings $800,000.

COMMUNICATION BETWEEN ENGLAND AND FRANCE.

A new impulse has been given to this ever-recurring question, by the fact that a French port was recently unable to give shelter to a mail steamer bound for the shores of that country, and which, after beating about the Channel for twelve hours, was compelled to return to the harbor from which it started. The various plans put forward for better communication, are classed by the "Mechanics' Magazine" under one of three heads —submarine, transmarine, and supermarine. Under the first are included the tunnel and the tubular projects, the difference between them being that the tunnel whether of iron, masonry, or brickwork, must be placed in the earth, whereas the earth must be piled around and on top of the tube. The tunnel must be excavated or laid under the earth; the tube lies along the surface constituting the bed of the Channel. The object of the covering of earth over the tube in either instance is the same, viz., to preserve the top from being injured by ships' anchors, dredgers, sunken vessels, or other external disturbances. Of these two methods, the tube would probably have the advantage in point of time, but great difficulty would attend the junction of the several lengths. The transmarine classification embraces two plans,—that of a solid embankment and that of a gigantic ferry. A solid embankment, as it must be sufficiently high to be above the level of the greatest wave, partakes of the nature of the third class, and might also with propriety be termed intramarine. This plan is altogether Utopian. Neglecting aerial means of transit, a bridge is the sole representative of the third category.

The objections to the tunnel and tube are, the unsubstantial character of the scheme, the complete uncertainty of the time to be occupied in its construction, and the total want of precedent. Assuming that everything proceeded as favorably as possible, it would take nearly twenty years to finish the job, calculating that the rate of progress could not be greater than that at present obtained at Mont Cenis. On this subject "Engineering" says: "Setting aside the difficulties of such a work, the inextricable complications which would arise between the two countries in the event of the peaceable relations between France and England being interrupted, and the precarious length of life of the tunnel if completed, the length of time its construction would involve, the enormous outlay of capital, and the enormous loss upon locked-up money lying idle during the formation of the work,—each of these reasons is sufficient to dispose of the tunnel question forever. Moreover, during the 20 or 30 years such a scheme would require for completion, the necessities of the increasing traffic would certainly be satisfactorily accommodated, and the millions expended upon the tunnel would have been literally thrown into the sea."

The ferry scheme of Mr. John Fowler is as follows: It is proposed to construct at Dover a harbor of about 24 acres extent, protected on the east by the old pier, and on the south by a new pier carrying a railway. A suitable harbor would be constructed at Calais or more probably near Cape Griz Nez, where there is deeper water. The vessels to be 450 feet by 85 feet over all, and 53 feet beam, and to draw 12 feet. The engines to be 1,200 nominal horse-power, and the speed some 20 miles an hour. The trains are to be run bodily upon the boats, as in the American system. Four vessels, costing £120,000 each, are contemplated. Of this scheme the "Mechanic's Magazine" says: What is required is a connecting link between the two shores which is totally independent of the intermediate barrier, and this result is manifestly not obtained by the agency of a ferry. It is an alteration of the present arrangement in degree only, not in kind. For a time it would be considered a great boon, but so soon as the novelty had worn off, the feeling would arise that it was, after all, but a makeshift—a temporary expedient—and we should return to the reconsideration of the more permanent systems now claiming public attention.

Of the bridge scheme, the same authority says: Allowing about 1,000 feet for the width of the spaces, they would be, in round numbers, double those of the Britannia Bridge, while the height of the piers above high water would be but a mere trifle in excess of the Britannia piers. Every engineer will admit that the difficulty is not in the superstructure, but in

the foundations ; but from the result of borings recently made, the substratum appears to be favorable to their being got in. And whatever circumstances of foundation and soil favor the construction of a tunnel, are doubly advantageous to that of the bridge, and, consequently, if no difficulty is to be experienced in that respect for the tunnel, the argument against the difficulty of getting in the piers falls to the ground. When light-houses, constructed entirely of iron, and supported upon iron piles, have been erected far out at sea, it is absurd to talk of the great and almost insuperable difficulty of getting in foundations elsewhere in similar situations. Besides, it would not be all the piers that would give the same degree of trouble, but only those situated remotely from either shore. Another advantage of a bridge would be that its construction and its utilization could proceed *pari passu*, and there would be no necessity for waiting for its completion, as in the case of a tunnel, before its services could be availed of. As each successive span commencing from the shores was finished, it could be used as a jetty, and year by year the opposite coasts would be in closer contiguity. In adopting the project of a bridge, there is not the slightest necessity for departing from any of the recognized types of construction, either in the sub or superstructure.

The proposal lately put forward by a French engineer, Boutet—and given place to in such publications as the "Journal of the Society of Arts" and the "Pall Mall Gazette"—the scheme of floating foundations and spans of a couple of miles, is simply a chimera, and would not stand the test of theoretical, much less practical analysis. M. Boutet, says "Engineering," "proposes to cross the Channel from the Shakspeare Cliff to Cape Blanc Nez, by a bridge with 10 openings, or clear spans, each 3,282 yards long, the platform of which is to be 360 feet above the average sea level. He proposes to construct his 9 iron piers upon the shore, to float them into place, fastening them to the bottom with screw-piles, and covering the structure with gutta-percha to prevent the adhesion of barnacles and the deterioration of salt water. And he proposes to lay out the course of the bridge to which the piers are to be hauled and sunk, by a buoyed rope, stretched from France to England. From this range of stupendous summits, nearly two miles asunder, M. Boutet stretches cables 2 inches in diameter, and of iron, not steel ; from 30 to 120 of these cables are ranged vertically 20 inches apart, the larger number over the piers being reduced to the lesser in the centre of the span. The cables are woven together with smaller diagonal wire ropes, and cast iron is thrown in when it is of no service, because, we presume, it looks well in the drawing, and gives an air of security to the flimsy web. The lower side of this "tress," as the projector terms it, is curved, but there is no compression member designed, and, moreover, none *could* be designed which should resist the enormous strain of the structure, and give the only value which could be given to the rest of the clumsy contrivance. More than that—and this is a point which the dullest disciple of Boutet can understand—the projector proposes to give rise to these trusses of 6 in 1,000, and so to obtain an increased rigidity. Now, it is absolutely impossible to stretch a wire between two points, however close they may be together, without deflection, because the strain required to do so is infinite, and in such an extreme case as M. Boutet proposes, the cables would break from their own weight long before any approximation to a horizontal line was obtained. In fact, allowing the extreme amount of strength to his cables, and assuming that they could be made perfectly homogeneous throughout, it will be found that the strands would part in the centre before they were within 500 feet of a horizontal line, in other words, the point of rupture would be attained when the cables had still to be hauled up 500 feet to get them into position."

Some reasonable sort of bridge, however, would appear to be the only feasible continuous work that could be built. It would cost perhaps twice as much as a tunnel—the rule of cost is stated to be three times as much for bridges as for tunnels—but it would be completed in a reasonable time. Thousands of men could work upon it, while tens of men were at work on a tunnel.

But before the bridge question is settled, years before the bridge is completed, the comfort of millions of passen-

gers is to be secured, and the transhipment of millions of packages of goods avoided, at a comparatively small expense, by the running of suitable boats between England and France. Undoubtedly the ferry system, however complete, will be inadequate 10 or 20 years hence; but during that period there should be at least as decent, comfortable, and economical communication as there is, for instance, between New York and Newport—a longer, and in parts more exposed route than that across the Channel.

LEAD IN TIN VESSELS.—A report has been published on the tin and tinned vessels used in the military hospitals in France. The metal used for tinning, it was found, contained from 25 to 50 per cent. of lead. In vessels reputedly made of pure tin, the Commissioner found, in some cases, as much as 15 per cent. of lead. Such proportions are dangerous, he says, to the public health, and the Government is recommended to fix a standard allowing only 5 or 6 per cent. of lead to be used with tin in utensils intended for culinary purposes, or for drinking-vessels. The author has probably over stated the dangers from the use of utensils composed as he has found; but it would be well if cheap manufacturers in this country would bear in mind that it is not altogether safe to use a large proportion of lead.

EXPLOSIONS in gas works, and in buildings where gas is leaking, as well as in mines, may be prevented by the use of the Davy lamp. Explosions are often caused in dwellings, by looking for leaks in meters and pipes with an uncovered lamp. At New Village, Mass., five men were recently killed by the explosion of a gas holder which they were repairing. The Davy or the Strive safety-lamp should be kept ready for use in gas works, and in all large buildings, such as hotels and theatres, where gas leaks are likely to occur.

PRATT, WHITNEY & CO.'S MACHINE WORKS, HARTFORD, CONN.—The machine shop is 220×45 feet, 3 stories, and employs 150 men. Machinery to turn out 500 rifles per day has recently been completed for Austria.

CONCRETE BUILDINGS.

Compiled from the "American Artizan," "The Engineer," etc.

The increased cost of building materials, has of late led to renewed and extensive experiments with concrete. This material has in various forms been employed for ages, and is said by travellers to be found hard and undissolved after 3,000 years of exposure among the temple ruins of Nineveh.

This concrete was in all probability composed simply of a lime mortar, tempered by treading with the naked feet of the laborers until it became tough and homogeneous, and then mixed with broken stone or rubble.

Many attempts have been made in this country to use a material of this character in the construction of buildings, but owing to the slight degree to which the management of the material in large masses has hitherto been understood, it has in many instances cost quite as much as brick; the comparative slowness with which the water is eliminated renders the wall liable in our northern climate to be suddenly disintegrated by frost. Because concrete has answered well in foundations, the conclusion has been too hastily arrived at, that it would therefore be equally suitable for houses. The duty it has to perform in the former case is to transmit the superincumbent pressure to the ground; and the only resistance that the material is called upon to display, is that against crushing. To secure rigidity and stability in unsupported walls, requires peculiar care and knowledge in selecting and compounding the materials. All artificial monolithic masses labor theoretically under the common disadvantage of their soundness being in the inverse ratio of their size. Not only is this true for artificial, but also for natural substances. These facts have led to the disuse of concrete for binding rubble into the form of walls, and the adoption of building blocks which are made of such size that one man may readily handle them, and which are simply bricks of concrete. This system also allows of the introduction of "bond," which does not, strictly speaking, exist in the rival principles, and there is, therefore, the absolute necessity for introducing binders, and joists, as soon as possible, in their case. The composition of these blocks differs from that

of the ruder concrete in the addition of hydraulic or Roman cement, by which their hardening is much facilitated. The blocks are formed in wooden molds, and require in their manufacture only a moderate degree of skill, the material being made by combining, in a wet condition, caustic lime, cement, and sharp sand in about the proportions of 1 bushel of lime, 6 of sand, and 4 quarts of cement. The blocks require considerable time to harden solidly throughout, and should be kept under shelter. Some manufacturers facilitate the manufacture, and also the hardening, by mixing the ingredients by machinery, by means of which steam and hot water are injected into the plastic mass while mixing.

Recent experiments by a German investigator seem to show that the costly hydraulic cement may be dispensed with, when the blocks are not placed under water, by employing a kind of mortar made of slaked lime and finely sifted sand. Caustic lime, equal to $\frac{1}{4}$ of the sand used, is mixed with the mortar when required for use; the heat resulting from its addition induces the formation of silicates, which quickly harden the mortar.

It has been suggested that, inasmuch as the hydraulic cement heretofore so largely employed, owes its efficacy to the silicate of alumina contained therein, an artificial cement may be made for the purpose, by properly mixing lime with 20 per cent. of dry clay.

A modification of the "block" system, is the slab system. The difficulties attendant upon it appear to be, principally, the impossibility of ensuring the perpendicularity of the upright portions of the house, the squareness of the angles, or the sharpness of the arrises. The idea of attempting to raise walls 20 feet and 30 feet in height, by means of small angle iron uprights and slabs of concrete, from 3 inches to 4 inches in thickness, is a simple absurdity. The house consists of nothing but panelling, and one is puzzled to decide whether one is really inside or outside, as the walls appear to have literally no consistency or solidity.

For facilitating the construction of solid concrete buildings, a Mr. Drake has taken a patent in England, for the use of flanged iron plates, supported by iron uprights secured against the face of the wall, such plates to be shifted upwards step by step upon the uprights, and locked to them in the several positions by pins. He also claims angle plates to form the angles of walls; also the use, to connect the front and back plates and uprights, of metal straps with pinholes in them at various distances, so that the length may be adjusted to the thickness required.

Several extensive structures are now erecting in England by the solid method, among them a large warehouse in London 70 feet by 60 feet by 50 feet, which will no doubt prove a success, because the work is carried on under the superintendence of those who thoroughly understand the subject, both theoretically and practically. The Duke of Northumberland is constructing a solid cottage of Portland cement concrete. The foundation set on sand, is 6 inches thick and 18 inches wide; the walls are 9 inches in thickness and 2 stories in height. The roofs are all flat, and are constructed entirely of concrete and old wire rope. The ceilings are divided into panels by ribs at right angles, and require no plastering. A wall on the upper floor is supported on a concrete beam, 13 feet span; a large cistern is formed under the roof, its sides being the walls of a room; this will severely test the impermeability of the material. No wood is used except for doors, and no iron, except the old wire-rope.

GOLD AND SILVER.—A recent estimate makes the total quantity of gold, in the form of coin, jewellery, vessels, utensils, in fact in all shapes, in the hands of man, equal in value to £1,200,000,000 sterling. This would be 300,000,000 ounces, or 30,000,000 cubic inches. If converted into a single block, its dimensions would not be less than 26 feet square, and its weight 10,500 tons. In the shape of sovereigns placed in a single line on the ground, each coin being in contact with its neighbor, £1,200,000,000 sterling would form a track 4,300 miles in length.

The value of the silver in use is set down at £1,000,000,000 sterling in value. This, in round numbers, would be 4,000,000,000 ounces, or 400,000 cubic feet, measuring 100 feet square by 30 feet in height. In the shape of shillings, placed in contact and in line, the globe itself would be more than twice encircled by this amount of silver.—*Mechanics' Magazine.*

WATER-SUPPLY FOR CITIES.

IMPORTANCE OF PURE WATER—SEWAGE—ARTESIAN WELLS—PARTICULARS OF EXISTING WORKS—PUMPING MACHINERY.

From the excellent report of Chas. Hermany, Esq., Chief Engineer of the Memphis Water Works, we compile the following considerations and facts on this subject, and they are especially interesting and important to the inhabitants of towns not yet well supplied with pure water:—

One of the first and leading considerations in the selection of abiding places for man, whether it be the cave of the savage, the hut of the barbarian, the cottage of the peasant, the camp of the soldier, the residence of the man of wealth, or the site of a large city, is the supply of an ample quantity of pure and wholesome water. Nature, however liberal, does not always make ample provision for supplying the wants of man, inasmuch as springs, brooks, and rivers are not sufficiently numerous to furnish water of suitable quality *everywhere* where man chooses abiding places; hence his ingenuity or constructive ability is called into action, and wells are formed by excavations in the earth from which water is obtained for limited numbers in localities more or less remote from natural water-courses.

Quality of Water.—In cities where large populations dwell upon comparatively small areas of land, this mode of obtaining water fails, both as regards quantity and quality. Upon the sites of many towns and cities, wells wholly fail to furnish water of suitable quality; hence rain-water cisterns, constructed under ground, and located in streets, courts, alleys, yards, basements, etc., into which that portion of rain falling upon the roofs of the houses, and not evaporated or absorbed, is conducted and stored for use. These modes of water-supply are very expensive, considering the limited quantity and deteriorated quality furnished. The principal cities of the United States, in times of sickness or epidemics, had the *prevailing diseases* to much greater extent, and much more aggravated cases, by virtue of the fact that limited quantities of indifferent or bad water aided climatic causes in developing and prolonging epidemics. In the city of New York, as early as 1798, while the necessity of a supply of pure water was already severely felt, Dr. Brown, in a report upon the subject in the same year, "exhibits circumstantially the consumption of water as of a very small quantity (on account of the difficulty of procuring it), and subordinate quality; he considers this as the cause of a variety of diseases and contagious disorders, especially the yellow fever, which had recently made great ravages there. He also considers the state of health of a populous city as depending *more upon the purity of its water* than the quality of all the rest of its provisions together."

In the city of Philadelphia, as early as 1793 or 1794, Benjamin Franklin was, it is believed, the first who publicly called the attention of the citizens to the subject of watering the city from some other source than the wells then universally used; urging that the afflictions from the ravages of contagious diseases rendered it necessary that a more copious supply of water should be procured, to insure the health, comfort, and preservation of the citizens. This was just after the city had been visited by the yellow fever. And in Franklin's will, dated June 23, 1789, is the following clause: "and having considered that the covering of the ground plot of the city with buildings and pavements, which carry off most of the rain, and prevent it soaking into the earth, and renewing and purifying the springs whence the waters of the wells must gradually grow worse, and in time be unfit for use, as I find has happened in all old cities, I recommend that at the end of the first 100 years, if not done before, the corporation of the city employ a part of the £100,000 in bringing by pipes the water of the Wissahiccon Creek into the town, so as to supply the inhabitants."

To sum up all the advantages from a properly devised public water-supply, would require a lengthy dissertation upon the subject; we will therefore briefly enumerate some of the principal ones only.

1. It furnishes a better quality of water than is possible from wells and rain-water cisterns, and at a much cheaper rate for the same quantity than can be obtained by private or individual means of supply.

2d. It encourages a liberal use of wholesome water by all classes, and thereby induces habits of cleanliness and

comfort, diminishes sickness, and in times of epidemics it has proved by the experience of other cities to be the greatest protection to densely populated districts.

3. By the constant command, at all hours of the day and night, of an unlimited quantity, for protection against the ravages of fire, it reduces the risks for insurance companies, and with that the rates of insurance, and in this way, perhaps more than in any other, is a well-regulated public water-supply productive of pecuniary advantages, which annually amount to a very liberal percentage on the capital invested.

4. It invites settlement, and encourages the investment of capital in manufacturing enterprises, which, by fostering productive industry, tend to build up the city in the elements constituting permanent wealth and independence.

As to the quality of the sources of supply, the report says: All the natural water-courses in every country become more and more impure with the increase of population, and less suitable for distribution in densely populated cities; and the best practice of hydraulic engineering, in its application to public water-supplies, is to collect and store the water as near as practicable to the gathering grounds, upon which it falls in the shape of snow and rain, and thence convey it artificially to the place of distribution. The truthfulness of this is illustrated by the following-named examples of water-supplies to towns and cities in the United States, where the water is collected and stored in reservoirs near the limits of the drainage areas supplying them, viz.: the Boston and Charlestown water-supplies in Massachusetts; the Albany, Croton, and Brooklyn water-supplies in New York; and the Hartford, Ct., and Baltimore, Md., water-supplies. The last two of these have changed within the last few years from taking their daily supplies from natural water-courses to storage reservoirs approaching the limits of the drainage areas supplying them with water. The Loch Katrine scheme, supplying the city of Glasgow; the Rivington Pike scheme, supplying Liverpool; the Birmingham water-supply; and the contemplated change in the mode of supplying the city of London with water, are cases in point, and demonstrate the justice and propriety of this view of the subject.

Sewage.—As the congregation of large numbers of human beings upon comparatively small areas has been shown to defile the spring and well water, as also the rain-water, by causing it to absorb in its fall the noxious gases which constantly arise from populous cities, as well as from the washings of the roofs, consisting of an almost endless catalogue of articles prejudicial to health, thereby compelling a supply being obtained from a source beyond the reach of city defilement, it must not be concluded that with the procurement of pure water the evil is remedied; it is only one of the effects which is obviated, for the evil itself continues to grow with the increase of population, until the earth or subsoil of the city is so thoroughly permeated with human excreta as to render its removal an absolute necessity; to accomplish which end, capital and industry, under the direction of the civil engineer, have constructed systems of sewers, through which, with the water from public water-supplies and rains as vehicles, the refuse, etc., from dense populations is carried to running streams and rivers, to be diluted to an extent which makes it harmless. Hence a system of thorough drainage, through the medium of sewers, is next in importance to a public water-supply for a city as a means of preserving the health of its inhabitants. This is a subject upon the investigation, development, and perfection of which the ablest statesmen, scientists, and engineers of great Britain and the continent of Europe have been engaged for years; and in the United States, also, much attention has been given to the subject, although the literature or written experience in relation to it is quite meagre. In a late publication* upon this subject the author truthfully remarks: "The general standard of public morals always corresponds with the state of public health, the latter depending again upon abundance of food combined with a pure atmosphere and an unlimited supply of undefiled water. * * *

In nothing is the superior wisdom of the present Emperor of the French so manifest as in the undivided attention he,

* Kropp's London Sewerage.

like the founder of his dynasty, pays to the sanitary, agricultural, industrial, and commercial interests of his people, which thus manifestly proves that true statesmanship finds its best allies in agriculture and public health."

The tables 1 and 2 give respectively, the quantity of water consumed, and the cost and other mechanical features of water-works in various cities. Table 3 gives the particulars of the principal artesian wells. Table 5 gives the duty of several of the best engines in the country, and is taken from the report of Jas. P. Kirkwood, C. E., on the Brooklyn water-works.

TABLE 1.

YEAR.	CITIES.	Each Inhabitant, per day.	Each Consumer, per day.
		Gallons.	Gallons.
1867	Charlestown, Massachusetts	41.83	54.33
1867	Brooklyn, New York	.....	*47.10
1866	Cleveland, Ohio	22.35	24.26
1867	Detroit, Michigan	48.46	54.47
	Chicago, Illinois	50.00	.....
	Cincinnati, Ohio	.....	.....
1864	St. Louis, Missouri	.....	*54.01
1866	Louisville, Kentucky	16.81	73.96
1864	New York	62.00	.....

TABLE 2.

CITY.	YEAR.	POWER.	Different Level between Source and Delivery	What Portion of Pumping Capacity Daily Required.		Cost per Million gallons elevated 100 feet.	Order of Economy.
				Maximum.	Average.		
Cambridge, Massachusetts	1866	Steam	72½	.....	.....	$18 02	10
Charlestown, Massachusetts	1865	Steam	135	0.228	0.177	14 97	6
Hartford, Connecticut	1866	Steam	120	.....	.....	16 34	8
Brookly, New York	1866	Steam	161	0.440	0.380	12 84	4
Jersey City, New Jersey	1866	.....	159	0.285	0.269	9 63	1
Fairmount, Philadelphia, Penn.	1866	Water Power	...	1.000	0.605	2 00	0
Schuylkill, Philadelphia, Penn.	1866	Steam	115	0.414	0.290	13 00	5
Delaware, Philadelphia, Penn.	1866	Steam	112	1.000	0.806	22 00	13
24th Ward, Philadelphia, Penn.	1866	Steam	...	1.000	0.615	9 91	2
Germantown, Philadelphia, Penn.	1866	Steam	...	0.272	0.215	23 10	14
Cleveland, Ohio	1865	Steam	158	0.200	0.154	17 55	9
Cincinnati, Ohio	1866	Steam	165	0.712	0.546	18 09	11
Louisville, Kentucky	1866	Steam	144	0.200	0.123	16 14	7
Chicago, Illinois	1865	.....	125	0.540	0.354	12 20	3
Detroit Michigan	1867	.....	75	0.410	0.360	18 20	12

THE ARTESIAN WELL, sending forth a constant stream of pure water, is a beautiful and interesting sight; and in the popular mind it is invested with a great degree of novelty. What is an artesian well? Historically, it is so called from a mode practised in Artois, a province in France, by boring for water. Technically, an artesian well is a mode for obtaining a spontaneous flow of water, at or above the surface of the earth, through the medium of a tubed perforation of the earth's crust, extending in depth until a body of water is reached, from which, by hydrostatic pressure, a portion is delivered through the tube at or above the surface of the earth. The most plausible theory, explanatory of the flow of water

* Approximate.

from artesian wells, is their similarity to natural springs, there being in both contracted apertures from the surface of the earth to the subterranean reservoirs full of water, and compressed by columns of this liquid. Through these apertures (natural fissures in the earth in the case of springs, and artificial borings in the case of artesian wells) the water escapes, seeking its level. The history of artesian wells, so far as they have been resorted to as a means of supplying towns and cities with water, is not at all encouraging, whatever may be their merits as means of obtaining limited quantities of water for private or special uses.

TABLE 3.

Artesian Wells.

NAME.	LOCATION.	Depth of Well.	Diameter of Bore at Bottom of Well	Quality of Water.	Temperature of Water.	Length of Time in Boring Well.	Elevation of Discharge + or − Surface of Ground.	Discharge per 24 hours, in U. S. gallons.	Total Cost of Well.	First Cost in measures of 1,000,000 gallons in 24 hours.
FOREIGN:		Feet.	In.		°Far.	Yrs.	Feet.			
Grenelle	Paris..... ..	1,806	6	Fresh ..	82½	7	..	175,104	$70,180 00	$401,028 00
Passy	Paris.....	....	..	Fresh ..	..	..	+66	2,188,800	.....	.....
Kissengen....	Bavaria	1,878	..	Mineral	66	..	+58	1,077,120	32,263 00	30,050 00
Aire	Artois, France	....	..	Fresh ..	..	..	+11	360,000	.....	.....
UNITED STATES:										
Charleston...	South Carolina	1,250	3	Salt ...	87	..	+10	30,000	20,000 00	666,666 66
Belchers	St. Louis.....	2,199	3½	Salt ...	73	5	−30	108,000	20,000 00	185,185 18
Du Pont's...	Louisville, Ky.	2,086	3	Mineral	..	1½	+170	330,000	10,000 00	30,303 03

TABLE 4.

Summary of the Estimated Costs of the Three Different Plans proposed for Memphis.

BRANCHES OF WORK.	Wolf River Plan.	Mississippi River Plan.	Hatchie Lake Plan.
Wolf River Aqueduct.....	$933,332 51	.....	.....
Inlet and river work.....	.....	$342,231 78	$191,862 66
Buildings at pumping station.....	67,872 60	230,135 20	230,135 20
Pumping machinery.....	100,000 00	225,000 00	260,000 00
Settling reservoirs	373,327 90	280,533 00	310,016 41
Pipe system.....	505,886 60	483,339 60	903,089 60
Distributing reservoir	349,009 10	349,009 10	349,009 10
Totals.....	$2,329,428 71	$1,910,248 68	$2,244,112 97

TABLE 5.

Duty of several of the principal Pumping Engines in the United States.

Date of Experiment.	Hours.	ENGINE.	Pounds Lifted One Foot High.
January, 1860....	26	Brooklyn engine, Cornish.....	601,407
January, 1857....	12	Belleville engine, Cornish	628,233
January, 1857....	8½	Hartford, Crank	587,793
July, 1857....	17¾	Hartford, second trial, first experiment.....	614,426
July, 1857....	12	" " " second experiment	646,994
April, 1857....	9	Cambridge, "Duplex"	669,411
June, 1857....	14¾	" " second trial	675,746
June, 1856....	48	Spring Garden, Philadelphia, Cornish	589,053

The following extracts are from a report by V. Dumas, member of the French Academy of Sciences, to the Minister of Public Works, on the subject of the exclusive water-supply of Paris by artesian wells:—

"The commission is unanimous (against the scheme). Among its members there are none who are unaware of the importance of artesian water drawn from the green sand for the use of Paris. But among those who base upon it the greatest expectations, there are none who are of opinion that it would be advisable to exclude the employment of other resources that nature or art has placed at the disposal of the Parisian people. * *

"1. The water-bearing stratum of green sand is not the exclusive property of the city of Paris. It can be operated upon at any distance or level by the proprietors of the soil. The works constructed by companies, associations, and individuals, however great or indisputable may be the capabilities of this source, could absorb them and render them of very doubtful application to the municipal wants.

"2. The phenomena and natural accidents, such as earthquakes, that exercise little influence upon canals through which flows surface water, could, on the contrary, produce on channels for the passage of water at great depths a derangement of their course.

"Though such events may be rare, it is sufficient to know that once in twenty years their effect on the well of Grenelle has been observed, not to be willing to expose the city of Paris to receive suddenly and for entire months turbid water in all its reservoirs, or to submit to a diminution of one-half the product of its flowing wells, which, though it were but temporary, would not be the less serious.

"3. The art of boring is not yet advanced enough by experience in tubing very deep wells of large diameter, especially in what concerns the green sand basin; tubes in iron do not last; copper tubes even, lined with tin, might fill the people with anxiety in times of epidemic; wooden tubes are uncertain; and wells not provided with tubes have not been thoroughly experimented with.

"4. The water of the artesian source, which is of great purity, and which, so far as mineral substances are concerned, is better suited than all others for industrial and public use, is very slightly aerated and tepid. It would be necessary, therefore, to cool and aerate it, to render it useful for domestic purposes; and for this reason it would be regretted that it is not a little richer in carbonic acid and carbonate of lime.

In conclusion, when we talk of supplying 2,000,000 inhabitants, it is prudent to assure ourselves of the simultaneous use of bodies of water taken from various sources, in order to be always ready to quiet the complaints of the people. Water, as we have said, ought never to be suspected; and, in case of the least doubt, the administration must be able to replace one water, though suspected without cause, by another which may possess the confidence of the consumers.

The Memphis Works.—The plans proposed for the supply of Memphis are:—

1. A supply from Wolf river, taken at the most available point above the town of Raleigh.

2. A supply from the Mississippi river, drawn at the first suitable point above the city.

3. A supply from the Mississippi river, taken in the vicinity of Hatchie Lake.

The Pumping Machinery recommended in the report for the Wolf River Works, is the Worthington Duplex Pumping Engine. The report says:—

This machine is strictly a steam pump, consisting of two steam cylinders and two water cylinders laid horizontally in pairs, the piston rod of each steam cylinder extending to its water cylinder and working a water-displacement plunger; the steam and water cylinders being separated a sufficient distance to permit the requisite mechanical devices to be attached to each connecting rod between the steam piston and the water plunger, for working the steam valves and air-pumps; the connecting rod of the right-hand engine working the steam valves and air-pump of the left-hand engine, and *vice versa*.

The machine is self-contained, and does not require expensive masonry foundations; it works horizontally; has the smallest mass of inert matter in the moving parts, being just sufficient for the safe transmission of the power; and thus, in conjunction with its moderate velocity, reduces its liability to accidents to a

minimum. The valves are multiform vulcanized rubber disks, strengthened by perforated cast-iron disks, the rubber seating upon grated composition-metal valve seats; the receiving and delivery valves are disposed in sets vertically one above the other, and rise and fall vertically.

In the economical use of fuel this engine compares favorably with the best pumping-engines in the country; and in its daily performance it will give moderately good results, with perhaps less attention from skilful enginemen than any other kind of pumping-engine now in use, being nearly automatic in its operation. It has been in use for a number of years, and there are at present in successful operation as follows, to wit: 1 pair at Harrisburg, Pennsylvania; 1 pair at Greenwood Cemetery, Long Island; 2 pairs at Cambridge, Massachusetts; 2 pairs at Charlestown, Massachusetts; 1 pair now being erected at Salem, Massachusetts; and 1 pair at Newark, New Jersey; the last 4 named being each capable of elevating 5,000,000 gallons water per 24 hours.

Wherever this pumping-engine has been in use, it has given entire satisfaction, and, with the exception of the Cornish pumping-engine, it has been duplicated a greater number of times than any other engine for water-work purposes, despite its recent origin.

PREVENTION OF SCALE IN BOILERS.

Translated from Dingler's Polytechnic Journal, by John B. Pearse.

In a late meeting of the Society of German Engineers for the Westphalian District, this subject was proposed for discussion. The remarks were opened by Dr. List, who divided all the means for its prevention into two classes : 1st, those consisting in the addition of various substances to the feed water; 2d, those consisting in the use of special apparatus. The former class of means includes among many others the use of starch or substances containing it, which shall cause the precipitation of the solid matter as powder or mud and not as scale. The results obtained by the use of starch were unfavorable according to the experience of a member. Dr. List mentioned the use of a soft greasy variety of clay, more or less mixed with bituminous matter (Halloysite). Mining Inspector Schrader stated that such clay had been advantageously used at several coal mines with which he was acquainted. Dr. List supposed that the particles of solid matter on being precipitated were taken up by or clung to the clay, instead of adhering to the bottom and sides of the boiler.

Dr. List also mentioned the use of various substances containing tannin. Their utility might be explained both on mechanical and chemical grounds. He had himself obtained favorable results from their use in water containing lime. In sugar factories the addition of crude molasses to the water had had a good effect.

As far as the chemical action is concerned, the utility of such additions depends on the composition of the water. If the latter contains gypsum or sulphate of lime, scale is formed, because the relative quantity of gypsum increases as the water is evaporated, and because the solubility of the same decreases with the heat of the water. If the water contains double or bicarbonate of lime, this compound is decomposed by the heat, and the simple carbonate is precipitated as scale.

The *gradual* separation of these substances causes the formation of scale. Chemical means may prevent such separation, or may hasten it so much that mud is formed instead of scale.

Sal-ammoniac is recommended for preventing the precipitation of lime by forming the readily soluble chloride of calcium. This means is frequently used, particularly in Holland, for locomotives. The most natural means, however, for water containing bicarbonate of lime, would be to hasten the precipitation by the use of a solution of slaked lime in water, or "lime water." This would separate all the bicarbonate of lime as an insoluble mud. Chloride of barium would be the best addition to waters containing sulphate of lime, or those from many coal mines, and would act in a similar way.

Carbonate of soda is recommended from actual experience as an effectual means of preventing scale from water containing either carbonate or sulphate of lime.

M. Helmholy remarked that he had

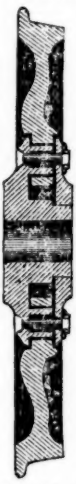
observed incrustations in Giffard's Injector, where the motion of the water was quite rapid. M. Weistman had also observed scale at point, where the velocity of the water was considerable, but mentioned the absence of scale in the boilers of steam fire engines. M. Kamp had also observed the deposition of scale in feed water pipes, although the deposition in the boiler was inconsiderable.

The translator has observed a case where it was attempted to blow charcoal through tubes by means of air, possessing considerable velocity. It was found that although the wind would take along with it some considerable quantity of charcoal, it would nevertheless deposit a good deal again, before reaching its destination, particularly at places where there were angles, or the pipes expanded slightly. The deposition of scale in the injector and feed water tubes might be thus explained without weakening the reasoning of Dr. List, which seems quite correct and conformable to experience.

ELASTIC RAILWAY WHEELS.

Over 10 years ago, that veteran Locomotive Superintendent, Mr. George S. Griggs of Boston, commenced using blocks of wood an inch thick, forming an almost continuous tyre, between the iron tyre and the cast-iron driving wheel rim of his locomotives. The results have been well defined and entirely good and economical, and they have certainly not been arrived at without due trial. The wear of tyres and the breakage of wheels and connected parts has been decidedly lessened by the interposition of this elastic medium, slight as is its yielding; and if of tyres, then of rails and permanent way, for although there may be 30 or 40 times as many truck wheels as drivers in a train, the drivers are 5-ton hammers, while the truck wheels are only little 2-ton smithshop hammers, that would not be employed by knowing smiths if the lamination of rails was the thing to be aimed at. Every body concerned has known all about Mr. Griggs' wheel for years, but it is only just now getting into general use.

Mr. W. Bridges Adams, of London, another veteran engineer, long since devised the "horse-foot" tyre—a steel spring between the tyre and the rim of the wheel, and although it gave good results, it has not yet been largely adopted. The wooden car wheel, with an iron hub and steel tyre, long used abroad, is just beginning to be appreciated here. It is in use on the drawing-room cars of the Hudson River Railway.



Another elastic wheel, for cars and other vehicles, a section of which is shown in the engraving, has been devised by Mr. John Raddin, of Lynn, Mass. The hub, and the web and tread are separate castings, between which there is interposed a ring of india-rubber. The holes in the web to receive the projections on the hub, are larger than the projections, so as to give a slight play—say one-eighth of an inch maximum. The rubber being compressed tightly in the annular space, cannot be squeezed out, but can only change its figure when the load comes upon it. The entire *jar* of the wheels is thus absorbed by the rubber before it reaches the hub and the axle. That both the running gear and the permanent way will be made safer and more durable by this elastic relief, is perfectly well assured by similar results in railway and other engineering practice. The economy of having the wheel in two parts, so that the tread may be renewed without forcing the hub from the axle, is obvious. The theoretical advantages of an elastic wheel will not be questioned by intelligent practitioners. Are there any practical defects or weaknesses in this method of application? The management of the Eastern Railroad say that after running 8 of these wheels for 9 months under a 22-ton iron car, an examination showed the rubber uninjured and the nuts all tight, though the bolts were not headed. The same wheels since placed under a passenger car, have run, in all, 40,000 miles with decidedly less wear on the tread than solid wheels. The Engineer of the Boston Fire Department gives an equally good account of similarly cushioned fire-engine wheels.

The use of elastic media between parts subjected to jarring, is now so well understood by railway managers, that we expect to see other and better applications.

Here is a large field for experiment and invention. Although the uniform elasticity of permanent way should be much better provided for than it is, the cost of a pair of well-appointed cushions upon each of a hundred million railway sleepers, looks rather formidable. The proper cushioning of a thousandth part of that number of the heaviest-loaded wheels of engines and trains, is more likely to be accomplished, and would do more good in proportion to the cost.

BRITISH RIFLED ARTILLERY.

Rifled guns had been experimented upon in England for about half a century before they were put to any practical test, but when the Russian war was imminent, it became necessary to adopt some form of rifled artillery, in order to oppose the rifled small-arms which began to be generally adopted. Metallurgy and mechanics had been improved in consequence of the stimulus given to these sciences by the great demand for efforts of civil engineering, and without these improvements the manufacture of rifled ordnance would have been impossible. When the war with Russia broke out, some 8-inch and 68-pounder iron guns were bored on Lancaster's system, and sent to the Crimea and to the Baltic, but they were of small avail, as the straight-sided projectile often jammed in their spiral bores.

It was in the Italian campaign of 1859 that rifled artillery was first used with any effect. The Emperor of the French, with his muzzle-loading bronze rifled field guns, did great execution, especially at Solferino, and scattered terror in the Austrian ranks more by the range than the accuracy of their fire. This success induced all European Powers to turn their attention to rifled artillery. Austria adopted the French system, while Russia and Prussia became converts to a breech-loading action invented by Mr. Krupp. England turned her attention to a breech-loading system invented by Mr. Armstrong, of Elswick. His guns were tested by the rough usage of war in China in 1860, and acquitted themselves admirably. It was known then that the Armstrong guns were excellent, and exceeded in range and accuracy those of any Continental Power. It was vainly thought that this system would have been permanently adopted into the service, at least for field artillery. The same system of ordnance did good service in New Zealand in 1864, but, though no enemies could stand against it in the field, it had potent antagonists at home.

In 1863, under the pressure of polemical writings, the Secretary of State for War appointed a committee to examine and report upon the different descriptions of guns and ammunition brought forward by Sir W. Armstrong and Mr. Whitworth. This committee sat for two years, and conducted a series of experiments, which cost £35,000 in stores alone. The total expenses cannot have amounted to much less than £60,000, and the result was that the experiments were very creditable to both inventors. The contest was very close; and surely no country but England, when it had a gun better than that of any Continental nation, would have spent £60,000 in investigating the infinitesimal differences between it and the offspring of some rival inventor. Still we did so; and the committee which was called on to decide this question thought that muzzle-loading guns, which had been already six years in the French service, were superior to breech-loaders for the service of field artillery. This opinion necessitated another committee to decide on the rival merits of muzzle-loading or breech-loading field artillery. In 1866 another committee assembled to discuss this question, and decided that muzzle-loaders were better adapted for field service than breech-loaders. The consequence was, that a muzzle-loading gun slightly different from the French gun was considered the proper gun for our field artillery, on account of its simplicity. We had thus spent at least 7 years and lost vast sums of money in determining theoretically that a gun which had been adopted at the outset by the French was better than our own, which had been proved to be most excellent on two separate occasions in active service. Yet when we had obtained this decision we could not act upon it, as we dare not incur the expense of arming all our field batteries afresh with muzzle-loading guns. This is the plain result to which we have attained in field artillery; of heavy guns

we propose to speak at a future time. The money which has been squandered in experiments cannot be recovered; it is hopelessly lost; and, of course, in a short time, in consequence of the decision of the last committees, unless, indeed, they are subverted by those of some future bodies, our breech-loading field artillery will be supplanted by muzzle-loaders.

Yet is there much reason that this expense should be incurred? It would, perhaps, have been better to have adopted a muzzle-loading gun in the first instance; but, now that we have a breech-loader, is it worth our while to incur all the expense and inconvenience of changing our armaments in order to gratify the whims of theorists or the fancies of mathematicians? The breech-loading gun has been found to do good service in China and New Zealand, and is undoubtedly far above the average as a gun. In the late German war the breech-loading gun triumphed over the muzzle-loader, and the victorious Prussians have adopted it it universally into their service. Impartial and experienced judges, who saw it in action, have told us that the breech-loading gun of the British artillery proved itself superior in China to the Prussian gun in Bohemia. It is, no doubt, superior to the Austrian muzzle-loader, which is very similar to the French gun. Why should we, then, incur a great deal of expenditure to change our armament, when we can already more than hold our own against that of any other nation? Metaphysicians and fanciful artillerists may aim at perfection, but we cannot afford to adopt every momentary invention which professes a very small advantage over the system already adopted into the service. We might, possibly, if we were to reconstitute our whole system, institute muzzle-loaders, and so reap all the fruits of our experience; but now that we have a gun in the service which is considerably better than any possible antagonist, we must deprecate the expense necessary to change for any fanciful advantage. We must remember that, ere the muzzle-loader can be made our armament, some new invention which will nullify it may be brought forward, and, happy in the goodness of our bad bargain, we may be quite content to let well alone.—*Army and Navy Gazette.*

Locomotives of the North London Railway.—The standard engines of this line are fully illustrated in the "Engineer," Dec. 11 and 25. They have 2 pairs of connected drivers 5 feet 3 inches diameter, and 8 feet apart centres. The truck has 4 wheels, 2 feet 8 inches diameter and 5 feet 8 inches apart. The centre of truck is 9 feet 10 inches from the centre of forward driving shaft. The boiler shell is 4 feet 1 inch inside diameter by 10 feet 2½ inches long, and contains 122 tubes 2 inches diameter. The fire-box is 4 feet 5½ inches long by 3 feet 7½ inches wide by 5 feet 4 inches high inside. The cylinders, outside, and inclined 1 in 12, are 17 inches diameter by 2 feet stroke. The steam-chests are inside, and the link-motion valve connection is direct. The tanks (1,000 gals.) are at the sides of the foot-plate and in rear of the boiler. The working steam pressure is 160 pounds. The peculiar and strong cylinder fastenings, and the great extent of the rubbing surfaces, are especially referred to. The weight of the engines is as follows;

	Light.		Full.		
	tons	cwt.	tons	cwt.	qr.
Bogie, four wheels	15	14	14	14	2
Driving wheels	11	11	14	5	0
Trailing wheels	11	7	14	12	2
Total	38	12	43	12	0

Five of these engines are now completed or in progress; they easily take trains consisting of 30 wagons, each weighing over 5 tons, and containing 10 tons of coal, and 2 heavy brake vans, or about 460 tons in all, up inclines of 1 in 100 in all sorts of weather. Equilibrium slide valves are used on these and all the new engines of this line with great success. The valve has the equivalent of 2 pistons in the back. Two circular flanges project from the back, nearly up to the steam-chest cover. Around these are packing rings which are forced up against the steam-chest cover, with a small pressure due to their area, thus making a tight joint. The area enclosed by the ring is open to the exhaust passage of the valve.

Aluminium Bronze is used in France for saws and other mechanism requiring great strength and hardness, in place of steel. It has been proposed to cover the steps of the column in the Place Vendome with the same material.

ORDNANCE AND NAVAL NOTES.

WHITWORTH GUN—LATE EXPERIMENTS. The longest range of cannon shot ever attained, was made by the Whitworth ordnance at Shoeburyness in November last, viz.: 11,300 yards, or nearly 6½ miles. The longest range previously recorded, was obtained in 1861 by Lynall Thomas' 175 lb. shot with a 25 lb. charge, from a 7 in. steel gun at 37½° elevation, viz.: 10,075 yards.

The Whitworth gun referred to, has 9,025 in. (major) and 8.25 in. (minor) hexagonal bore, 140.06 in. long with 1 turn in 117 in. The shells used were cast iron, 31.6 in. long, 8.96 in. major, and 8.18 in. minor diameter, with capacity for 18 lb. bursting charge. The shot were cast iron, 24.5 in. long. The wads were hexagonal; weighing 1 lb. each and made of paper maché. Large grained rifle powder was used. The result of the firing was as follows:

No. of Shot.	Weight of Projectile, lbs.	Weight of Charge, lbs.	Elevation.	Range, yards.	Time of Flight.	Deflection, yards.
1	310	50	10°	4,868	13.5 sec.	1 L
2	250	50	10°	5,196	14.2 sec.	7 R
3	310	50	10°	4,021	12.1 sec.	6.2 R
4	250	50	33°	11,300		
5	250	50	33°	11,234		
6	310	50	33°	11,075		
7	310	50	33.5°	11,127		

NEW BRITISH GUN.—An order has been issued from the War-office announcing the introduction into the service of a new description of wrought iron muzzle-loading 10 in. 18-ton gun, of which the following is the official technical description:—Length of gun, 14 ft. 2 in.; mean weight of gun, 18 tons 24 lb.; mean preponderance, 3 cwt. 1 qr. 24 lb.; length of bore, 145.5 in.; length of rifling, 118 in.; calibre, 10 in. The "A" tube is to be made of tough steel. This new description of ordnance is of the general type represented by the 7, 8, and 9 in. guns. They are rifled upon the Woolwich system with seven grooves, having a twist increasing from one turn in 100 calibres at the breech to one turn in 40 calibres at the muzzle.

The vent enters the bore at 11 in. from the end, and upon the right-hand side, at an angle of 45 deg. to the vertical axis on the transverse section, and directed to the axis of the gun. The vent consists of a steel bush, lined with copper, screwed in from the exterior against a platinum tip screwed up from the interior. This tip has a flange, or button-shaped head, projecting into the bore, as a means of preventing the gas escaping into the joint. A projecting head is left upon the bush to enable it to be removed when required by a spanner. The bottom of the vent is enlarged to a diameter of .32 in., tapering up to .222 in. (the diameter of the vent channel) in a length of one inch. The guns are sighted in the ordinary manner at a deflectional angle of 1 deg. 10 min., but this angle is only to be regarded as provisional. They are fitted with "plates, metal, elevating," and "pivots." The cascable faces are graduated for the Engineer of the road tangent scale use.

USE OF RAILWAYS IN WAR.—The movements by railroad of the Ninth corps under General Burnside, from Central Kentucky to Vicksburg; the transfer of the Twelfth and Thirteenth corps, under Hooker, from Washington to Chattanooga; of the Twenty-third corps from Eastport, on the Tennessee, to Washington, are remarkable instances of the usefulness of this new military arm. The last-named marvellous feat, Mr. Stanton declared to be "without parallel in military history." The distance travelled was 1,400 miles, the troops moved were 20,000 strong, besides 1,000 animals and a full artillery train. It was accomplished in mid-winter, with rivers and roads blocked by ice, in an average time of 11 days for each subdivision.

The campaign of 1866 in Germany demonstrated the importance of the part which railways are called on to play in modern strategy. The Federal Council of Northern Germany has had under consideration a proposition for the drawing up of a complete table of the resources and military advantages of the lines included in the Confederation. With this view a statement is to be compiled every two years, commencing with 1870, in accordance with an official formula, showing the capabilities, in a military point of view, of the existing railways and the branches to be constructed. An interesting work has been written on the subject in German. The Italians are busy organizing a system for turning their lines to the best use, and here engine-drivers and stokers are attached to every regiment.

USE OF BREECH-LOADERS ABROAD.—In the North German army the infantry of the line and the guard are all armed with needle-guns, of which there is also a sufficient supply for the reserve and for the garrisons. The arming of the whole of the landwehr with converted needle-guns was also decided upon last June. Of the South German troops, those of Hesse, Baden, and Wurtemburg are all armed with the needle-gun, while Bavaria only began a few months ago to supply the Werner gun to her army. Austria had armed 300,000 men with the converted Wanzl last July. The whole of the French army may be regarded as being supplied with the Chassepot since last spring. In Belgium the Albini gun was to be in the hands of every soldier of the line by the 1st of October. In Italy 32 battalions of bersaglieri were armed last July with a rifle similar to the Prussian needle-gun, with slight modifications. The English army has, since the beginning of the year, carried the Snider. The arming of the Danish army with the Remington rifle is also complete; and Russia makes the greatest efforts to hasten the supply to her troops of Carlen needle-guns. Of the other States, Holland, Sweden, Roumania, and Servia have only just introduced breech-loaders into their respective armies, while in Turkey, Spain, and Portugal the soldiers still carry the old musket.—*Cologne Gazette.*

U. S. ORDNANCE REPORT.—The expenditures of the Ordnance Department during the last fiscal year, for all purposes, inclusive of the pay-

ment of war claims, were a little more than three millions—less than three-fifths of the expenditure of the preceding year.

There are 27 military arsenals in all, including the National Armory at Springfield. The work done at them by the hired mechanics and enlisted men of the Ordnance Corps, under the direction of skilled officers of the corps, has been economically and satisfactorily performed.

Highly favorable reports of the breech-loading converted Springfield musket have been received from those portions of the army where it has been distributed.

A few smooth-bore and rifle guns, of heavy calibre, are being made, for trial of their power and endurance. When the most suitable kinds have been determined, a large number of guns for fortifications will have to be made, and authority to make them as fast as can be done is asked.

TORPEDOES.—Further experiments have been made at Toulon with torpedoes, and it has been decided that in case of war, that port shall be strongly defended with these submarine monsters. The Government, however, thinks that the torpedo subject is one which should be confided to a special corps, and hence a school is to be established at the Isle of Aix, where the mysteries of those engines of destruction will be taught.—*Army and Navy Gazette.*

UNITED STATES AND BRITISH SQUADRONS.—At the date of the report of the Secretary of the Navy, we had on duty with our various squadrons, 38 vessels, including storeships, mounting in all 347 guns. On December 5th, the English had, within the limits of their several stations, 116 vessels, mounting in all 1,146 guns. From this it would appear that, besides their Channel fleet, the English have three cruising vessels in squadron service to our one.

NEW ENGLISH MONITOR.—The "Cerberus," recently launched at Jarrow, and designed by Mr. Reed, is 225 feet long by 45 feet 2 in. beam, and 18½ feet deep, the draft being 15½ feet. There are 2 turrets, 21¼ feet diameter. The turrets stand on central spindles and are revolved by auxiliary engines. Each turret carries two 18 ton 450 pdr. Armstrongs. The hull is divided into 7 water-tight compartments. The vessel is to go to Australia.

THE CHRONOSCOPE.—A series of experiments carried out at Woolwich with the new chronoscope for measuring the velocity of projectiles within the bore of the gun invented by Captain A. Noble, late of the Royal Artillery, have been attended, it is said, with great success. The instrument has proved itself capable of measuring the hundred-thousandth part of a second with great accuracy.

ORDNANCE EXPERIMENTS.—It is stated that Admiral Dahlgren, Chief of the Naval Bureau of Ordnance, will ask Congress for a limited appropriation to be used in experimental gunnery, as no appropriation has been made for this purpose for the Navy.

KRUPP VS. ARMSTRONG.—The German papers claim a decided victory for Krupp over Armstrong in the late trials of the rival systems. The English gun was shown to be inferior and split at the 264th round, while the German gun was fired 400 times without being damaged.

IRON AND STEEL NOTES.

USE OF MANGANESE IN STEEL MAKING.—Mr. Robert Mushet, in replying to a paper on iron and steel by Messrs. Hinde, says:

In their remarks on the effect of spiegeleisen, and of the preparations of manganese with carbonaceous matters, as set forth in Vickers' and Heath's patents, Messrs. Hinde have gone completely astray, and have fallen into the common error of supposing that spiegeleisen is added to oxygenated iron solely to recarbonize such iron. The fallacy of this opinion has been clearly shown where ferro-manganese in place of spiegeleisen has been used to de-oxygenate molten Bessemer metal, the results obtained being far better than when spiegeleisen is employed. Now, ferro-manganese contains only about one-fifth as much carbon as spiegeleisen, and nearly four times as much manganese, and were it possible to produce pure metallic manganese free from carbon, at a cheap rate, it would wholly supersede spiegeleisen, and would enable manufacturers of Bessemer metal to obtain from inferior numbers of hematite pig metal, steel of as good a quality as they now obtain from best selected pigs. Nothing but metallic manganese requires to be imparted to oxygenated iron to produce steel, and the use of compounds containing other matters, is simply due to the fact that a better or purer form of metallic manganese than is contained in spiegeleisen cannot be economically procured. Neither under Heath's nor under Vickers' process is metallic manganese added to steel. Oxide of manganese is the agent here, and its action is that of a flux. Thus, when blister steel, which, when melted and cast into an ingot, cannot be drawn into a sound bar, or bear a welding heat, is melted with a few ounces of oxide of manganese without any carbonaceous matter being added, and then cast into an ingot, the ingot thus produced can be drawn into a sound bar of steel, which will forge and harden well, and bear a welding heat. In the melting pot, therefore, oxide of manganese, and not metallic manganese, acts as an improver of the steel operated upon. As to either Vickers' or Heath's process being applicable where it is desired to de-oxygenate decarbonized iron, it is a myth.

PARK AND LOVE'S STEEL PROCESS.—This is an invention relating to the manufacture of cast-steel, and the furnaces used for that purpose, and also for remelting. The furnace consists of two fire chambers, separated by a fire bridge; one of these chambers receives a crucible, and the other contains a reverberatory fire chamber. Both chambers are in connection with the crucible, which is surrounded with fuel. The second chamber has a curved or arched top, to direct the flame into the crucible chamber to the fuel therein, or to the open mouth. The crucible is provided with discharge holes. After bringing both fires to a white heat, molten cast iron is poured into the crucible in such quantities as will form steel, together with malleable iron. Vitreous fluxes are introduced. Wrought-iron scraps, previously brought to a white heat in an adjoining furnace, are introduced into the cast-iron in the crucible. When the cast and wrought irons are mixed and melted together, the contents of the crucible are drawn off through the discharge holes. Puddling may be carried on in the furnace by making the working

hole at the top instead of at the side. The puddling instrument is an iron ball on a bar, worked up and down by chain and pulley, or by hand.

JAMES AND JONES' STEEL PROCESS.—Messrs. James (of Ebbw Vale) and Jones (of Govilan) have specified a patent relating to the manufacture of steel, under which they claim the application of carbonizing and nitrogenizing gases under pressure to wrought iron in a receiver closed gas-tight. These gases are formed in a separate generator, and thence forced into the receiver through an accumulator or otherwise, or the gases may be formed in the receiver itself, partially or wholly. The nitrogenous gaseous compound preferred is cyanogen gas. They also claim the use under compression of blast-furnace waste gases, containing carbonic oxide, ammonia, and nitrogen; also other waste gases containing the necessary elements for the conversion of wrought iron into semi-steel or steel.

THE SIEMENS-MARTIN PROCESS.—Messrs. B. Samuelson & Co., of Middlesborough, write to "Engineering" that they do not (as had been stated) remelt the ingots produced by this process, but roll them, without hammering, into soft steel plates, capable of resisting a tensile strain of from 34 to 35 tons per square inch, and into rails which have withstood repeated blows of a weight of 21 cwt., falling from a height of 26 feet. As to the use of Cleveland iron—whilst it has not been possible to use it for the bath, they have, by Richardson, Johnson & Co.'s process of purification, succeeded in freeing the puddled bar, made out of Cleveland iron, from phosphorus to a sufficient extent to obtain the results stated.

THE TEMPERATURES (centigrade) best adapted to the tempering of various instruments are seen in the following table:

Lancets	210°—215°
Other surgical instruments	220
Razors	225
Penknives, erasers	230 —235
Scalpels, cold chisels for iron	240
Shears, sheep shears, gardening tools	250
Hatchets, axes, plane irons, pocket-knives	260 —265
Table knives, large scissors	270 —275
Swords, watch springs	285
Large springs, daggers, augers	290
Saws, some springs	310 —315
Various other instruments requiring less hardening	320

CHROMIUM STEEL.—It has long been known that an alloy of 60 parts of chromium and 40 parts of iron is so hard as to scratch glass like a diamond, and such an alloy may be formed by heating oxide of chromium in a blast-furnace with metallic iron. Experiments are now being carried on to produce a species of steel, suitable for rails and other purposes, by adding chrome ore and manganese to the iron in the puddling furnace; and the results are said to be promising, though not yet conclusive.

CREUSOT.—The Bessemer process is being introduced on a vast scale, and 80 new puddling furnaces are being added to this immense establishment.

POWDER HAMMER.—If the following, which has "gone the rounds," etc., for a year or so, *works*, a description of the apparatus, mould stoppers, strength of parts, etc., it will be gladly and prominently quoted and credited by Van Nostrand's Magazine: A French periodical states that Mr. Galy Cazalat has invented an ingenious process for compressing molten steel, intended for guns, so effectually as to save all the labor of hammering. In the upper part of the mould into which the metal is run is an apparatus containing a small quantity of highly inflammable powder, which, in burning, generates gas in such quantity as to produce thereby, in a short time, a pressure of ten atmospheres. This pressure expels the gases contained in the steel, and forces the metallic molecules into the closest union.

IRON OR STEEL DIRECT FROM THE ORE.—In order to produce iron or steel direct from the ore, Mr. G. W. Nasarow, of St. Petersburgh, treats the ore with a solution of carbonate of soda in water, allowing the solution to stand a considerable time in contact with the ore. The weight of the carbonate of soda employed may be about one-fortieth part of the weight of the ore. The ore thus prepared is placed in a furnace—a reverberatory furnace supplied with a hot blast may be advantageously employed. The ore is melted down and iron or steel is obtained, according as the metal is allowed to remain in the furnace a longer or shorter time. The compact bloom obtained may be forged and rolled. Scrap iron may be treated in the same way, but in some cases it is necessary to add more carbon.

IRON FROM PYRITES.—Experiments are now being made in New York, with a view to the production of merchantable iron from pyrites. At a recent meeting of the Lyceum of Natural History, Professor Eggleston stated that the furnace employed is similar to an old Swedish furnace, very much cut away, and steam heat is employed; the material is kept in the lower part of furnace at a white heat, till agglutination takes place; the pasty mass is then skilfully worked and separated into grains, and afterwards withdrawn. He would not prejudge the case, but entertained no hopes of success.

MANUFACTURE OF STEEL.—Puddled bar is converted into steel, according to the invention of Mr. V. Gallet (referred to in the *Mining Journal*), by coating the bars with a paste composed of wood charcoal, 20 parts; soot, 12; lamp-black, 15; ivory black, anthracite, plumbago, 1 each; carbonate of lime, 33; carbonate of potash, 3 to 20 parts; carbonate of soda, 10; caustic potash, sea salt, sal ammoniac, 1 each; clay, 13; oxide of manganese, 3; and resin, 3 parts—the whole combined with water. The iron is coated with the paste, and the cementation conducted in the usual manner.

SHOTTING MELTED METAL, by pouring it into water, is largely practised, and is a very convenient way of reducing iron and steel for remelting. But if the mass of water is not very great compared with the mass of metal, and if it is not kept cool, the generation of steam will cause explosions. In several of the Bessemer steel works, where shotting steel for remelting in crucibles is practised, explosions of various intensity have oc-

curred—some simply throwing up the water and bursting the tank. In Silesia, recently, a shotting tank burst, killing and wounding several men.

COST OF BESSEMER PLANT.—Much is being said, just now, in connection with new modes of making steel, of the great cost of the Bessemer plant. Yet a plant capable of turning out upwards of 12,000 tons yearly, or 250 tons weekly, viz., a pair of 5-ton converters, with all machinery complete, costs but £6,000; the interest upon which, together with fuel, attendance, repairs, and depreciation, would hardly amount to half-a-crown a ton, whereas the cost of ingot moulds alone, necessary in all steel melting, by whatever process ingots are made, is as much as 4s. per ton. Of the Bessemer plant the cost of a double-blowing engine, with a pair of 3 feet steam cylinders and 4½ feet blowing cylinders, with a stroke of 5 feet, is £1,800, or, with boilers, less than £2,500. As compared with the cost of machinery necessary to work the product of such a plant, its own cost is very little indeed. For, with £6,000 outlay for Bessemer plant, £80,000 or so would be expended in the hammers, rolls, engines, boilers, and miscellaneous machinery, requisite for working up 1,000 tons of ingots monthly into goods.—*Engineering.*

THE PENNSYLVANIA STEEL WORKS.—It is now over a year since a charge of steel has been lost at these works through any failure of the machinery, tuyeres, vessel-bottoms, or refractory materials. To those familiar with the English practice, this will appear a remarkable result. It is due, of course, to good construction and careful management. The American refractory materials, as far as developed, are not equal to the English.

NEW AUXILIARY TO THE BESSEMER PROCESS.—John Francis Bennett, of Pittsburgh, has patented the use of carbonic acid gas, either alone or mixed with atmospheric air, or with other gases or vapors, when introduced into molten iron or other metal for the purpose of removing sulphur, phosphorus, and any other impurities which will form combinations with the oxygen of the carbonic acid, and deposit the carbon. It is said that this process is about to be tried at the works of John Brown & Co., Sheffield.

COSTLY STEEL-MAKING.—An invention explained at a recent Converzatione of the Institution of Civil Engineers, consists in grinding pig-iron to powder by a very rapidly revolving cutter. The great heat generated sets the particles of metal on fire, and after scintillating, they fall down in a reddish brown dust, which is gathered, placed in a crucible, and melted.

THE BETHLEHEM IRON CO. have purchased the Northampton (new) furnace near their works, and are adding a foundry and a new rolling-mill, with Siemens furnaces, to their already extensive plant, viz.: 2 blast furnaces, a rail mill, producing 90 tons daily, and a very large machine shop.

THE FRENCH RAILWAY AND NAVAL BLAST FURNACES, FORGES, AND STEEL WORKS COMPANY have introduced the Bessemer process for the manufacture of steel in their Givors Works.

RAILWAY NOTES.

RAILWAYS IN THE UNITED STATES.—The development of our railway system has been more rapid during 1868 than ever before. We have a nominal increase of 3,450 miles of road, costing $193,245,232. The actual figures are probably 3,000 miles at $150,000,000 cost. The following table shows the distribution of mileage and cost:—

	Miles of Road.		Cost of Road and Equipment.
	Total.	Open.	
Maine	944.19	559.67	$19,789,521
New Hampshire	783.72	668.72	21,975,319
Vermont	643.59	603.59	24,347,149
Massachusetts	1,537.06	1,4[illegible]5.43	69,345,521
Rhode Island	121.47	1[illegible]1.47	5,606,665
Connecticut	782.66	641.23	23,064,859
New York	4,459.53	3,328.87	182,538,123
New Jersey	984 75	972.75	69,770,243
Pennsylvania	4,937.72	4,897.74	256,772,257
Delaware and E. Maryland	362.90	242.94	7,483,566
Maryland (other than above)	654.75	457.45	28,520,899
West Virginia	605.85	364.75	22,401,100
Virginia	1,909.88	1,464.17	47,549,038
North Carolina	1 617.79	1,096.67	25,687,414
South Carolina	1,338.17	1,076.17	25,131,500
Georgia	1,977.60	1,574.60	31,369,075
Florida	613.20	440 20	9,294,000
Alabama	1,604.90	962.[illegible]0	28,511,726
Mississippi	909.20	909.20	24,545,303
Louisiana	837.30	379.50	11,321,[illegible]01
Texas	1,837.50	513 60	14,406,000
Arkansas	687.10	86.00	4,211,000
Tennessee	1,790 63	1,435.63	43,018,916
Kentucky	1,418.95	812.65	28,799,255
Ohio	4,053.41	3,351 97	169,014,101
Michigan	2.044.26	1,159.26	44,549,043
Indiana	3,246.10	2,600 10	104,[illegible]21,225
Illinois	4,561.55	3,4[illegible]9.95	156,968,102
Wisconsin	1,773.60	1,[illegible]34.60	48,[illegible]69,301
Minnesota	1,758.00	671.50	18,463,000
Iowa	3,032.70	1,822.00	61,332,000
Nebraska	449.03	420.00	21,000,000
Wyoming Ter	560.00	510.00	41 800,000
Missouri	1,857.09	1,353.80	64,014,458
Kansas	1,123.00	648.00	30,840,000
Colorado	350.00	....	350,000
Utah Ter	305.00	105.00	2,400,000
Nevada	390.00	320.00	25,600,000
California	2,691.50	468.50	30,336,000
Oregon	2,019.50	19.50	503,000
Total Jan. 1, 1869	62,917.10	42,[illegible]72 18	$1,853,706,041

Street railways, say 2,500 miles, and double tracks and sidings, say 25 to 30 per cent. on the whole, are not included in the above table. The total length of single track in the United States can therefore hardly fall short of 60,000 miles. This is the work of 40 years.—*Compiled from the Railroad Journal.*

BRITISH RAILWAY TRAFFIC AND MAINTENANCE STATISTICS.—The number of passengers carried in Great Britain in 1866, was 313,699,268, or an average of about 10 journeys by rail yearly for every man, woman, and child in Great Britain. In carrying these passengers 19,228 vehicles were employed, which ran 73,383,356 miles in 3,741,086 trains. It has been computed that to carry such a traffic under the told system would require about 50,000 coaches, and more than half a million of horses.

The number of persons travelling by railway in and out of London averages about 300,000 daily. Nearly 700 trains run over the Metropolitan line alone. The total number of local London trains per day is about 3,600, besides 340 trains which arrive from and depart to distant stations. During the busy hours of railway traffic, morning and evening, as many as 2,000 train stoppages are made hourly for the purpose of taking up and setting down passengers, while about 2 miles of railway are covered by running trains.

The annual loss of iron by tear and wear on the 13,854 miles of railway open for traffic in Great Britain amounts to above 20,000 tons a year, while about 250,000 tons require to be taken up, re-rolled, and relaid. The wooden sleepers, also, perish at the rate of about four millions per annum, to renew which about 10,000 acres of pine forest require to be cut down. To maintain the permanent way, about 81,000 men are constantly employed, at the rate of 5 men per 2 miles of double way. Besides these workmen, there are 13,000 plate-layers employed in laying down and fixing new rails; 40,000 artificers, who construct and repair the rolling stock; 26,000 porters, signalmen, and pointsmen; 6,000 guards and breaksmen; and 11,000 engine-drivers and firemen; or a total of about 177,000 railway workmen.

The heaviest item in the working expenses of railways is that for locomotive power. There were 8,125 locomotives at work in the United Kingdom in 1866, or about 2 engines for every 3 miles of railway open; and the work they performed during the year, was the haulage of 6 millions of trains a distance of 143 millions of miles.

The average working "life" of a locomotive is about 15 years, during which it will run about 300,000 miles, undergoing during that time many repairs and renewals; after which it may be considered used up, when it is sent to the scrap heap. Thus, taking into account the tear and wear of the locomotives at work in the United Kingdom, about 500 engines have to be replaced yearly; and as a good locomotive costs from £2,500 to £3,000, the expenditure on new engines amounts to about million and a quarter sterling yearly.

As to cost of working, a passenger engine will consume about 30 lb. weight of coke per mile, and a goods engine 45 lb. Hence the coal and coke used in 1866 was about two and a half million tons.

The average earnings of each locomotive amount to about £5,000 yearly, or equal to 5s. a train mile. According to a recognized formula, the working expense per train mile is 2s. 3d., which may be thus divided: 1s. for maintenance of stock, 3d. for maintenance of way, 9d. for coaching and goods expenses, and 3d. for miscellaneous expenses.—*The Quarterly Review.*

FAST RUNNING.—A train on the Chicago and Northwestern recently made the unprecedented run of 91 miles in 90 minutes. The quickest prior runs of which we have any record are as follows: In England 18 miles by a special train in 15 minutes. In the United States, 14 miles in 11 minutes, by an engine and 6 cars, on the New York Central; 10 miles in 7¼ minutes, on the Pennsylvania Railroad; 144 miles in 2 hours 49 minutes, on the Hudson River road; 84 miles in 90 minutes, from Indianapolis to Union City; 305 miles in 7 hours 42 minutes, from Albany to Niagara.—*Exchange.*

OREGON BRANCH OF THE PACIFIC RAILWAY.—It will require only about 330 miles of railroad to open a communication between the Union Pacific Railroad, near the north end of Salt Lake, and the city of Portland, in Oregon. The whole distance is 645 miles, but 300 can be travelled by steamboats on the Snake and Columbia rivers.

PERMANENT WAY OF THE LONDON METROPOLITAN RAILWAY.—All the rails on this line are of steel, weighing 84 pounds per yard, and resting on sleepers placed about 2 feet 8 inches apart, centre to centre, and 1 foot 10 inches apart at the joints, which are made with fish plates, and 4 bolts seven-eighths inch. diameter. The sleepers are bedded upon 14½ inches screened gravel.

TURKISH RAILWAYS.—The resources of Asiatic traffic are in a measure shown by the earnings of the Smyrna and Cassaba Railway, 61 miles long, now earning £2,000 a week, or nearly £33 per mile per week. During the week last reported, 4,696 passengers and 2,166 tons of goods were carried.

RAILWAY FERRIES are somewhat used in Great Britain. There is one across the Tay at Broughty, and one across the Forth at Granton. They are only for goods trains. The boats carry 25 short cars at a time.

DUTCH RAILWAYS.—A new link in the line from Amsterdam to Paris was recently opened—the Utrecht and Waardenburg—and the whole line is promised to be completed by the end of this year.

GOVERNMENT AND RAILWAYS.—A strong pressure is being brought to bear upon the British Government, in favor of buying the Irish railways upon terms submitted during the last session of Parliament by a joint committee.

MISCELLANEOUS.

RESOURCES AND WORKS OF PENNSYLVANIA.—The anthracite coal production of this State increased from 365 tons in 1820 to 12,650,671 tons in 1867. The bituminous coal field covers 1,300 square miles; the anthracite, 470. The production of pig iron, begun in 1720 in Chester county, has been increased and diffused until it amounted in 1867 to 839,496 tons. Pennsylvania is first among our States in the production of both coal and iron, and second only to Massachusetts in the range and extent of her manufacturing industry. She has 972 miles of canals, which cost $38,660,397, and 3,097 miles of completed railroads, which cost about $250,000,000, being foremost of all the States except possibly Illinois, in railroads, and before all but New York in canals.

SCALE IN LOCOMOTIVE BOILERS.—The locomotive superintendent of the Chicago and North-Western Railway, has for 3 years past succeeded, although using very hard water, in keeping his boilers free from scale by merely introducing once in about 3 months, 12 pounds of pure zinc, in pieces about one-half inch square. This appears to gradually clean the boiler, and to prevent the formation of fresh scale. The zinc

wholly dissolves in from 3 to 5 months, and the inner surfaces of the boiler plates are then found covered with a thin coating of zinc, as are also the ends of screws taken out for examination.

BROKEN SCREW SHAFTS.—It is but lately that the Hibernia was lost by the breaking of her screw shaft within the stern tube, the broken ends fouling and so forcing away the after-end of the shaft, thus admitting a flood of water into the hold. The Borussia, of the Hamburg American line, put back recently on her way to New York, with her screw shaft broken, but happily not inside the stern tube.

STRENGTH OF CORRUGATED IRON.—We devote this month more space than we shall ordinarily allow for a single article, to the comprehensive paper on this subject. It is a paper that can hardly be condensed, and as it is comparatively new matter, and likely to be frequently referred to, it will be more useful and convenient in this form, than if divided.

THE NEW YORK STOCK YARD at Communipaw covers, with its buildings, 15 acres of ground. The average market consumption of New York per week is, beeves, 5,500; of swine, about 21,000; of sheep and lambs, about 22,000. The capacity of this Abbatoir for slaughtering and dressing is: of beeves, from 6,000 to 7,000; of swine, upwards of 35,000; and of sheep, upwards of 25,000.

NEW BOOKS.—Under this head we intend to give, each month, the titles of all prominent new books connected with Engineering, together with a very brief abstract of reviews of them by our contemporaries.

THE NEW DAM AT COHOES across the Mohawk river will be the largest work of the kind in the State. It is 1,640 feet long, from 14 to 20 feet high, 16 to 18 feet wide at the bottom, and 10 at the top. Some 500 feet of the dam are completed.

ST. PAUL'S CATHEDRAL.—The total cost of the erection of St. Paul's Cathedral was £747,954 2s. 9d., less than $4,000,000. It is slightly larger than the New York Court House.

STEAMSHIP construction and engines will form the subject of a comprehensive article in the March number of this magazine.

THE COFFER DAM at Rock Island, is seven-eighths of a mile long, and from 8 to 14 feet wide, and contains a million feet of lumber.

SMALL LOCOMOTIVES for mines, quarries, stock yards, etc., to take the place of teams, are building by Grice & Long, Philadelphia.

NEW BOOKS.

SHIPBUILDING IN IRON AND STEEL. A PRACTICAL TREATISE GIVING FULL DETAILS OF CONSTRUCTION, PROCESSES OF MANUFACTURE, AND BUILDING ARRANGEMENTS; WITH RESULTS OF EXPERIMENTS ON IRON AND STEEL, AND ON THE STRENGTH AND WATER TIGHTNESS OF RIVETED WORK. By E. J. REED, C. B., Chief Constructor of the Navy, Vice President of the Institution of Naval Architects, and Honorary Member of the Liverpool Literary and Philosophical Society.

There are several excellent works, by distinguished authors, on this subject. Mr. Scott Russell and Professor Rankine, go very fully into stability and form of least resistance. Mr. Reed treats in a more comprehensive and practical manner of details of construction, and strength of materials and forms. The work is complete in one 8vo volume of 540 pages, and the excellent plan of having the illustrations inserted in the letter-press has been followed, thus avoiding the necessity for a separate volume of plates. There are upwards of 260 wood-cuts, and five steel plate engravings. The book is divided into chapters on the strength of iron ships: on keels, keelsons, and garboard strakes; on stems; on stern-posts; systems of framing, in various chapters; deck stringers and plating; bulkheads; topsides; rudders; iron masts; steel plates for ship-building; rivets; testing iron and steel; Lloyd's and rules for shipbuilding; armor plating, etc. The best evidence that can be adduced in favor of the practical nature of the work is that the Lords of the Admiralty have directed that the examinations in practical iron shipbuilding of candidates for promotion in the Royal Dockyards will, in the main, be based upon Mr. Reed's treatise.

"Engineering" says of the work:

Not only is it distinguished by its essentially practical tone, and the fullness of the information it affords with respect to details, but it also contains several other novel features, which, in our opinion, are well worth notice. One of these consists in the fact that, instead of giving the usual historical sketch of the progress of iron shipbuilding, that progress is traced in the notices of the various parts of the ship. For example, in the chapter on "keels, keelsons, and garboard strakes," there is given an account of the steps by which shipbuilders passed from the wooden and hollow iron keels and keelsons of the early ships up to the present arrangements. This course is followed throughout the work, and has the further interest of sometimes showing how arrangements which had fallen into disuse had been re-applied recently. Before the appearance of this book, no accurate and detailed account of the changes made in the construction of iron-clads, from the time of the Warrior's building up to the present, had appeared. This want has, however, been supplied most satisfactorily in the present volume. We find in this volume, also, fuller notices of the practice of private builders with respect to the various parts of iron ships than have ever previously appeared. Scarcely any of the great firms remain unrepresented.

SCIOGRAPHY, OR RADIAL PROJECTION OF SHADOWS. By R. CAMPBELL PUCKETT, Ph. D., Head Master of the Bath School of Art. London: Chapman & Hall, 193 Piccadilly, 1868.

This work is well reviewed by the "Mechanics' Magazine," which says:

Sciography, or the science of shadows, has never received that special attention it deserves. This is evidenced by many architectural drawings, where the attempt to unite the mechanical projection of shadows with perspective representations, produces many errors, and shadows of the most impossible character. To correct this tendency by

means of a text-book, has fallen to the lot of Dr. Puckett, who has well performed his part. The work is very properly limited to the perspective projection of shadows, and, therefore, pre-supposes a knowledge of linear perspective on the part of the student. It forms, therefore, a supplement to perspective studies.

THE MECHANIC'S AND STUDENT'S GUIDE IN THE DESIGNING AND CONSTRUCTION OF GENERAL MACHINE GEARING, AS ECCENTRICS, SCREWS, TOOTHED WHEELS, &C., AND THE DRAWING OF RECTILINEAL AND CURVED SURFACES, WITH PRACTICAL RULES AND DETAILS. Edited by FRANCIS HERBERT JOYNSON, author of "The Metals Used in Construction." Edinburgh: William P. Nimmo, 1868.

The "Building News" states that this book goes very fully and satisfactorily into the subject of shafting. The "Mechanics' Magazine" says: The student will find rules for the construction of the above parts of machinery, as well as practical rules and details for drawing rectilineal and curved surfaces. Of course, this work assumes an acquaintance with mechanical drawing. The details and calculations of shafts, pedestals, and pulleys, are carefully considered, after which we have a selection of geometrical problems. The volume is accompanied by eighteen sheets of diagrams.

A PRACTICAL TREATISE ON THE MANUFACTURE OF PORTLAND CEMENT. By HENRY REID, C. E. TO WHICH IS ADDED A TRANSLATION OF M. A. LIPOWITZ'S WORK, DESCRIBING A NEW METHOD ADOPTED IN GEEMANY OF MANUFACTURING THAT CEMENT. By W. F. REID. London: E. & F. N. Spon, 48 Charing Cross. 1868.

"The Engineer" says this is an excellent and thoroughly practical treatise. The "New York Tribune" says: "Among the chief merits of the book are extensive plagiarisms from Major-General Gillmore's standard American treatise on Limes, Hydraulic Cements, and Mortars. We presume the profession in America are perfectly willing to furnish material for the writers of books on the other side of the water, provided due credit is given, and the ordinary courtesy among gentlemen is observed in the matter."

A TREATISE ON THE METALLURGY OF IRON. Containing outlines of the history of Iron Manufacture, methods of assay, and analyses of iron ores, processes of manufacture of iron and steel, etc. By H. BAUERMAN, F. G. S. First American edition revised and enlarged, with an appendix on the Martin process for making steel, from the report of Abram S. Hewitt, U. S. Commissioner to the Universal Exposition at Paris, 1867. Illustrated with numerous wood engravings. New York: Virtue & Yorston, D. Van Nostrand.

This work has already had a wide circulation, and is officially adopted as a regular book of reference in one of our best engineering schools. For a comparatively small and cheap book, it is perhaps the best and most thorough work in print, on this subject.

EXAMPLES OF MODERN STEAM, GAS, AND AIR ENGINES. By JOHN BOURNE, C. E. London: Longmans, Green, Reader, & Dyer, Paternoster-row.

Parts VI. and VII. of this admirable treatise are now published. The author continues the discussion upon water-jet pumps and pumping engines. He then enters upon the subject of fire-engines. We next have a dissertation upon blowing engines. The plates which accompany parts VI. and VII. represent the slide, expansion and valve gear, and the boilers of R. M. S. "Russia," and the 15 horse power high pressure inverted screw engine, made at the Motala Iron Works, Sweden. The quality of Mr. Bourne's writings on the steam-engine and kindred subjects, is too well known to require comment.

PERSONAL RECOLLECTIONS OF ENGLISH ENGINEERS, AND OF THE INTRODUCTION OF THE RAILWAY SYSTEM INTO THE UNITED KINGDOM. By a Civil Engineer, Author of the "Trinity of Italy." London: Hodder & Stoughton, 27 Paternoster-row, 1868.

In closing a long review of this book the "Builder" says: The book which we have thus condensed will be found amusing, as well as instructive reading. Engineers and contractors will recognize in it many portraits, though the name be not written beneath the picture; and legislators will discover hints here and there deserving their attention. Other authorities do not consider the book as taking rank among scientific works.

MODERN SCREW PROPULSION. By N. P. BURGH. London: E. & F. N. Spon, 48 Charing Cross.

This treatise has reached Part X., in which the chapter on the modern details of screw propellers is concluded, and an interesting chapter on bearings, by Mr. John Penn, is given. Particulars and engravings are given of the experiments and apparatus, by which Mr. Penn proved the practical utility of wood bearings when submerged in salt water. The 3 plates accompanying this part illustrate the geometry of the screw propeller, a 3 bladed twin screw propeller, and the geometry of the Griffith's screw propeller.

IRRIGATION IN SOUTHERN EUROPE, BEING THE REPORT OF A TOUR OF INSPECTION OF THE IRRIGATION WORKS OF FRANCE, SPAIN, AND ITALY, UNDERTAKEN IN 1867-68 FOR THE GOVERNMENT OF INDIA. By Lieutenant C. C. SCOTT MONCRIEFF, Royal Engineers Assoc. Inst. C. E. London: E. & F. N. Spon, 48 Charing Cross.

A PRACTICAL TREATISE ON HEAT, AS APPLIED TO THE USEFUL ARTS; FOR THE USE OF ENGINEERS, ARCHITECTS &C. By THOMAS BOX, Author of "Practical Hydraulics." London: E. & F. N. Spon, 48 Charing Cross. 1868.

This is pronounced by competent authorities to be a valuable work.

A MANUAL OF PRACTICAL ASSAYING. By JOHN MITCHELL, F. C. S. Third edition, edited by WILLIAM CROOKES, F. R. S., etc. London: Longman, 1868.

This is a new and much enlarged edition of a standard work. It is an octavo volume of 780 pages.

A PRACTICAL TREATISE ON METALLURGY, adapted from the last German edition of Prof. Kerl's Metallurgy. By WM. CROOKES, F. R. S., etc., and ERNST ROHRIG, Ph. D., M. E. London: Longmans, 1868.